A STUDY OF THE BEAVER IN THE YANCEY REGION OF YELLOWSTONE NATIONAL PARK

By
EDWARD R. WARREN

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THE NEW YORK STATE COLLEGE OF FORESTRY, AT SYRACUSE

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All figures are from photographs and sketches by the author in 1921, 1922 and 1923, except figure 97, which is here reproduced through the courtesy of Mr. J. E. Haynes.

The field photo numbers are given in parentheses and may be referred to also on the accompanying maps where they designate photographic stations.

MAPS

All maps, except Map 1, are reproduced from drawings by the author, based on his surveys of 1921, 1922 and 1923. Photographic stations are marked by field photo numbers, the small arrows indicating direction in which the views were taken.

RESEARCH ON WILD LIFE

"The discovery of new species and races based upon the study of preserved specimens of game animals, has already progressed very far; but the more attractive field which includes the habits of the game remains yet to a great extent unexplored. This field is peculiarly open for investigation to big-game hunters, and to all other men who go far afield and obtain first-hand knowledge of the conditions under which the game animals live. The closet naturalist, with his technical knowledge of the structure of animals, can be trusted to perform the work of classification to a mathematical degree of precision; but we cannot obtain from him a trustworthy account of the behavior of animals in their natural environment, or learn from him the value to the animals of the various structures or characteristics which he has shown them to possess. Much knowledge regarding the habits of game is acquired by the successful sportsman. Yet it is often infinitesimal in quantity compared to what may be acquired if the outdoors observer will direct his investigations along the broad lines covering the life-history of the species with which he comes in contact. To carry out such investigations successfully it would be necessary to spend many hours and days, perhaps even weeks and months, observing certain individuals or family groups of game. This is quite beyond the limits of time alloted the average sportsman. Nevertheless much can be learned by the collected evidence from many fragmentary observations, providing only these are accurate. A great mass of accurate fragmentary observations will often spell far more progress in investigations of this kind than the observations of a few trained individuals over an extended period of time."

THEODORE ROOSEVELT and EDMUND HELLER.
Life Histories of African Game Animals,
Vol. I, pp. vii-viii, 1914

NATIONAL PARKS POLICY AND WILD LIFE

The service thus established shall promote and regulate the use of the Federal areas known as national parks, monuments, and reservations hereinafter specified by such means and measures as conform to the fundamental purpose of the said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.

An act to establish a National Park Service, and for other purposes. Public — No. 235 — 64th Congress, (H. R. 15522); 1916.

"For the information of the public an outline of the administrative policy to which the new Service will adhere may now be announced. This policy is based on three broad principles:

first, that the national parks must be maintained in absolutely unimpaired form for the use of future generations as well as those of our own time;

second, that they are set apart for the use, observation, health, and pleasure of the people; and

third, that the national interest must dictate all decisions affecting public or private enterprise in the parks."

FRANKLIN K. LANE.
Third Annual Report, U. S. National Park Service, p. 361; 1919.

Map 1. Topographic map of Yellowstone National Park. From U. S. Geological Survey atlas sheet, revision of 1921, reduced one third. The beaver studies conducted by the Roosevelt Wild Life Station in 1921 and 1923 were made chiefly in the north-central section of the Park (see also Map 2).

A STUDY OF THE BEAVER IN THE YANCEY REGION OF YELLOWSTONE NATIONAL PARK*

By Edward R. Warren

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* This paper in the first number of the *Annals* on the beaver of the Yellowstone National Park, embodies the results of an extensive survey by Mr. Edward R. Warren in the summers of 1921 and 1923. The project was undertaken with the approval of Hon. Stephen T. Mather, Director of the National Park Service, and with the interest and assistance of Mr. Horace M. Albright, Superintendent of Yellowstone National Park, and of Mr. M. P. Skinner, then Park Naturalist. The field reports for the two seasons have been combined to form the present paper. This study was made possible by contributions of funds and services from a number of interested persons.

The first part of the paper deals chiefly with the work of 1921, the field expenses of which were borne by the Yellowstone Park Camps Company, through the kindness of its president, Mr. Howard H. Hays. Mr. Warren and his field assistant, Mr. Ellis L. Spackman, Jr., donated their time and services. This part is the fourth contribution from the Roosevelt Station of a series of publications resulting from the interest and generous assistance of Mr. Hays. (Cf. also *Roosevelt Wild Life Bulletin*, Vol. 1, No. 1, pp. 96–99.)

The second part of the paper is devoted primarily to an extension of the survey in 1923, and to a consideration of the maintenance of the beaver as a permanent resource in the Park. This part was generously financed by members of the Board of Trade of the Fur Industry of New York City, through the active interest of Mr. David C. Mills, and forms their initial contribution toward a comprehensive study of our fur-bearing animals. Mr. Warren and his assistant for 1923, Mr. James E. Mills, donated their services in the field, and Mr. David C. Mills made a special contribution toward their field expenses.

In behalf of the Roosevelt Wild Life Station I desire to express my appreciation of the wholehearted cooperation from these friends of wild life conservation.—Charles C. Adams, Director (April, 1926).

INTRODUCTION

The beaver is coming to be recognized as an exceedingly interesting and valuable animal to maintain permanently in our parks and forests, and the public is but just awakening to the fact that despite the numerous books and articles written about this mammal there is urgent need for more detailed knowledge than we now possess. The successful management of wild life in our forests demands as a basis the most comprehensive and exact scientific study. Much has been published concerning the beaver, which, if not entirely fictitious, is nearly enough so to emphasize the importance of as accurate statements as possible about the creature's habits and life history. Many of the fantastic stories have been refuted long since but persist perennially in popular articles, written more to suit the editors' ideas of what is attractive than with any strict adherence to the facts. The truth about the beaver or other wild animals is, however, strange and interesting enough without resorting to false embellishments.

The following report is the result of a detailed field study of the beaver in the Tower Fall-Yancey region of northeastern Yellowstone National Park and a general survey of beaver works at certain other points in the Park during the summers of 1921 and 1923 (see Maps 1, 2). The investigation covered, to be more exact, the seasons from July 10 to September 6, 1921, and July 1 to September 1, 1923.

The paramount aim of the investigation was to make accurate descriptions, maps and photographic records of beaver inhabited sections of the chief streams in the region studied, including in detail the various beaver structures — dams, ponds, canals and lodges — so that these data might serve as a basis for future comparative studies. The field numbers of the photographs supplementing the descriptions have been placed also on the maps, with arrows indicating the direction toward which the views were taken, thus allowing accurate comparisons to be made in future from each photographic station. The real value of this was apparent from the striking changes noted in the beaver works and food tree cuttings between 1921 and 1923.

A brief popular account of the first season's work has already been published in an early number of the Roosevelt Wild Life Bulletin (Warren, '22). The investigations in the summer of 1923 extended the mapping only slightly, but particular attention was paid to changes that had occurred in the beaver works, and an effort was made to ascertain approximately the present beaver population, its food supply, and its outlook for the future. During this season our studies were confined mainly to the beaver colonies in the region about Camp Roosevelt which had been surveyed in 1921. I also examined the colony on the upper part of the South Fork of Elk Creek, near the Petrified Tree, as well as some tree cuttings along the Yellowstone River. My assistants made trips to Carnelian Creek, Slough Creek, and other nearby localities inhabited by beaver. Two colonies along Lava Creek, adjacent to the Park highway, were also studied in detail. On our way out of the Park at the end of the season we measured the famous old dam at Beaver Lake, and examined and photographed the remarkable cuttings near Lewis River Falls.

As will be seen from the comparative descriptions of the various colonies, pronounced alterations took place in the stream environments as a result of the beaver activities during the two years intervening between our investigations, and some of these changes appear to threaten the maintenance of the beaver in their present numbers. This matter, involving the question of remaining food supply and the determination of the age and growth of food tree species, is discussed in the final chapters of this report. The data secured on this aspect of the problem are merely suggestive but they indicate a large field for study before the preservation and control of the Yellowstone beaver can be assured.

I wish to express here my appreciation at having had the opportunity to make this investigation; to Dr. Charles C. Adams, Director of the Roosevelt Wild Life Forest Experiment Station, for his constant aid and encouragement; and to those donors, mostly unknown to me, who generously supplied the means which made the work possible. My special acknowledgments are also due to the following persons: to Prof. Alvin G. Whitney of the Roosevelt Wild Life Station, who assisted me in the field work during late August, 1923, visiting certain localities which I had been unable to reach; to Superintendent Horace M. Albright of the Yellowstone National Park, who kindly furnished me information about various localities, particularly the beaver work along Lewis River, which proved unusually interesting; to Mr. M. P. Skinner, formerly the Park Naturalist, who has given me much valuable data concerning the beaver in the region studied; to Mr. John Bauman Park Ranger, for notes on the beaver in 1924 and 1925; to Mr. Howard H. Hays, President of the Yellowstone Park Camps Company, and the staffs of his hospitable camps, for their many courtesies; to Mr. Henry Lambert, an experienced hunter and trapper, and a keen observer, for information furnished me about the wild life of the Park; to Mrs. Agnes Chase, Assistant Agrostologist of the Bureau of Plant Industry, U. S. Department of Agriculture, for identifying specimens of grasses; and last, though by no means least, to my capable and congenial field assistants, Mr. Ellis L. Spackman, Jr., of the University of Colorado, in 1921, and Mr. James E. Mills of New York City, in 1923, without whose willing aid I could not have accomplished as much as I did.

GENERAL DESCRIPTION OF THE YANCEY REGION AND PROBLEM

The Region and Methods of Study. The beaver colonies and works described in this report, with the exception of those on Lava Creek, Beaver Meadow, and Lewis River, are located within a radius of a few miles of Yanceys and Tower Fall in the northeastern part of Yellowstone Park (see Maps 1 and 2). They are easily accessible from Camp Roosevelt, a hospitable tourist camp near the Tower Fall Ranger Station. Most of the colonies are located on fairly small streams or their branches, and chiefly along Elk Creek, Lost Creek and Tower Creek. The Yellowstone River Bridge Colony and Yancey Meadows are within a few minutes' walk of the Ranger Station. Upper Lost Creek and Lost Lake are one-half to one mile distant by trail, among the hills 200 feet above Camp Roosevelt and the Ranger Station. The Petrified Tree Road Colony and the South, Middle and North Forks of Elk Creek, as well as the Crescent Hill ponds,

are from one to three miles northwest and easily reached by good roads and trails. The Tower Creek and Carnelian Creek Colonies are located several miles above Tower Fall and are not so accessible, requiring a day's rough trailing on horseback. To examine the beaver works on the streams flowing from the south and west slopes of Buffalo Plateau, five to eight miles away, necessitates a day's horseback trip from Camp Roosevelt by a roundabout route.

The immediate physical surroundings comprise low hills and ridges, with ravines and valleys of greatly varying width and steepness. Some ravines carry perennial streams, while many are dry most of the year (Fig. 2). These hills have little or no timber on the dry south slopes, as a rule, but are covered with grass and sagebrush (*Artemisia*), while the slopes with a northern exposure, flanking the higher hills to the west, have good stands of the conifers — Douglas fir, Engelmann spruce and lodgepole pine — as well as groves of aspens. Douglas fir, pine and aspen are found along most of the beaver-inhabited streams, the aspen being the main source of food for the beaver. The detailed characteristics of the environment of the various beaver colonies are described later. No two of the colonies are alike in their local conditions, but each presents its own points and problems for special study.

With the exception of a few places on Tower and Carnelian Creeks, all of the groups were surveyed with sufficient accuracy for plotting correctly the dams and ponds, and for future study and reference. This survey was made with a small open-sight compass; all the bearings taken were magnetic, and the maps have been platted according to these needle courses. Without such surveys it would have been almost impossible to have obtained a correct idea of the different ponds and dams in relation to one another, to say nothing of their actual dimensions. The surveys and maps should be of much use to future workers in showing what changes have taken place from year to year.

In connection with these surveys careful notes were made as to the construction of the various dams, canals, and lodges; the character of the trees and other vegetation in the vicinity; the topography; the cutting and utilization of trees by the beaver; and considerable time was devoted to detailed observations of the animals themselves in the ponds near the Yellowstone River Bridge (1921) and on the North Fork of Elk Creek (1923). In short, notes were recorded on everything bearing on the life history of the beaver that came to my notice.

In 1923 the works studied two years previously were again examined carefully and all changes noted, including the extension of ponds and new construction of dams, etc.; the abandonment of former works and colony sites; and the depletion of the aspen supply and invasion of fresh areas. Particular attention was given to a study of the sudden and extensive cutting of Douglas fir trees and the utilization of this species as food. The colony near the Yellowstone Bridge having been abandoned, particular attention was paid to the colony on the Upper North Fork of Elk Creek for detailed notes on habits and behavior. The general survey was extended to other parts of the Park, particularly to colonies along Lava Creek near the Park highway, to Beaver Lake Meadow near Obsidian Cliff, and to the remarkable lodgepole pine cuttings below the Lewis River Falls.

Localities of Beaver Works Surveyed. The following brief descriptions of localities studied will indicate the general conditions along beaver streams in

Yellowstone Park. It is notable that most occupied works are on small streams or spring runs. It is probable that the turbulent condition of the larger streams in late spring and early summer, due to the rapid melting and run-off of the winter's snow, is the reason for this location of the beaver colonies. The dams would not withstand the high water and swift water of the swollen streams.

1. *Yellowstone River Bridge Creek.* The colony here was located on the small stream paralleling the Cooke City road near the present Yellowstone River bridge (one-half mile above the former Baronett Bridge). The works extend along the road for a quarter of a mile in a narrow ravine (Map 3, Figs. 2, 3), about ten minutes' walk from Camp Roosevelt and the Tower Fall Ranger Station. They comprise about twenty rather small ponds and dams. The difference in elevation between the highest and lowest ponds is approximately one hundred feet. The beaver first began work here about 1912, according to Mr. M. P. Skinner, the former Park Naturalist, so that a study of this colony gives some idea as to the amount of work which the animals will do in a ten-year period. This was a particularly fine place to observe the habits of beaver in 1921, but it was abandoned in 1922.

2. *Upper Lost Creek.* This is the section of Lost Creek above the 70-foot fall half a mile back of the Tower Fall Ranger Station and about two hundred feet higher. The stream lies in a narrow valley with a moderate grade and high, steep slopes on either side. The works comprise many old, unused dams as well as a number of dams and ponds now occupied by the beaver (Map 4). There has been extensive tree cutting on the slopes. The principal pond contained three lodges in 1921, but great changes have taken place there since then.

3. *Lost Lake.* This is a narrow but fairly deep lake two-thirds of a mile long, lying between low hills on the bench two hundred feet above and back of the Tower Fall Ranger Station (Map 5). It is half way between upper Lost Creek and the end of the Petrified Tree Road. The government maps do not show this lake. It is of natural origin, though a low dam across the marsh at the outlet has raised the level somewhat. The upper and lower quarters of the lake are overgrown with grass, and the middle two-fourths is open water bordered by a zone of yellow pond lilies.

4. *The Yancey Meadows.* These extend from the Ranger Station nearly a mile to Yanceys, the historic ranch, now long since abandoned. They are fine examples of beaver meadows, and especially interesting because we have some definite records showing their later development and the length of time it has taken to form them. The area was partly occupied by beaver ponds in 1897 when Ernest Thompson Seton studied them in detail. Seton later published a map and field sketches of these works, in his Life Histories of Northern Animals, 1909. According to Mr. M. P. Skinner, the former Park Naturalist, the ponds were abandoned about 1903 or 1904, so that parts of these fine meadows have been formed within fifteen or twenty years.

5. *South Fork of Elk Creek, at Yanceys.* Just above the ranch buildings at Yanceys on the South Fork of Elk Creek is a group of small beaver works, located on sloping, swampy ground (Map 6). The ponds are therefore narrow, lengthwise the stream. At least one of the dams is very old, and there is a long canal extending from the main pond.

6. *Petrified Tree Road Colony.* This colony is located on the upper part of the South Fork of Elk Creek, below the branch road to the Petrified Tree. The uppermost pond is about opposite that interesting ancient monument. There is a series of about 20 ponds, only part of which were in use in 1923. One of the drained ponds contained a large lodge which was cut into and examined carefully (see diagram, Fig. 45). The possible food tree supply along the stream was about exhausted, and the beavers were cutting the few large remaining aspens about the new upper ponds.

7. *Elk Creek Bench Colony.* The Bench colony is located on the middle fork of Elk Creek (Map 7), on a flat through which flowed the tiny stream fed by springs in the heavy Engelmann spruce above. The aspens farther down where the ravine is steep and narrow, were cut long ago, and the wrecks of old dams are to be seen there. The activity on the bench began, however, in 1920; but most of the work was done in 1921 and 1922, lodges being built in the new ponds, and a considerable part of the adjacent grove of large aspens being cut in those years.

8. *North Fork of Elk Creek.* This branch of Elk Creek lies in a valley of varying width and grade. As in the case of the Middle Fork, the beavers long ago cleaned out the aspen on the steeper lower course, and the present felling and building is at the headwaters of the stream on flat ground (Maps 8, 9). Above the old abandoned dams the works now occupied include the longest dam now in the Yancey region. This series of ponds and dams is also peculiar in that above the long dam are two converging groups, one on the stream itself, and the other in a swampy area fed by springs or seepage several hundred feet to one side. Some distance above the ponds now occupied, are a few old abandoned dams on the same creek. Still farther up, on the tiny branch coming from the foot of Crescent Hill is another fresh series.

9. *Crescent Hill Pond Series.* This colony (Map 11) is characterized by a very large pond at the source of the stream, between the steep south slope of Crescent Hill and a low ridge to the southeast. There is a series of smaller ponds and dams along the grassy run and ravine lower down. The actual source of the water appears to be springs in the large pond and in the glade above it. No aspens now remain near the big pond, and the dams below are of such recent construction as to indicate the moving of the colony downstream to the unharvested supply of aspens there. In 1923 the beavers began extensive cutting of Douglas fir at the uppermost pond.

10. *Beaver Colonies in Natural Ponds.* Besides Lost Lake, a good example of a lake somewhat enlarged by beaver, there are several smaller ponds similarly utilized. In some cases they have no appreciable inlets or outlets, and require no control for the beavers' needs.

A short distance northeast of the Crescent Hill colony, on the other side of the ridge from the large upper pond, is a natural pond which was inhabited by a beaver colony in 1921 and 1923. In the former year there was one lodge, in 1923 two lodges, in this pond, and much cutting was being done among the aspens. Considerable groves of large aspen still stood close to the pond at either end and along the west side.

A long and narrow pond, perhaps a mile northward of the one just mentioned, lies near the head of a small brook flowing northward into the Yellowstone River. Neither pond nor brook are shown on the Geological Survey topographic map; but for our purpose they may be designated as North Crescent Pond and Creek. This is a natural pond bordered by a rock talus slope on the east and fringed with large Douglas fir growth on the west. The aspen had been cleared out long ago, and wholesale cutting of the Douglas fir was in progress in 1923 along the shores.

In a steep gulch below the Yancey barns, on the upper right side of lower Elk Creek, is a small natural pond containing an abandoned lodge, but still frequented by beaver.

11. *The Tower Creek Works.* The chief colony on Tower Creek (Map 12) is about three miles above Tower Fall. The dams and ponds are not located on the Creek itself, which is evidently too large and swift during floods for a dam to hold, but lie alongside the stream on the flat below a very deep spring, practically all the water of which is utilized in the series of ponds. This flat is subject to flooding from the creek during high water. The present occupied works were constructed within the last five years. In the largest pond, above a very long dam, is a mammoth lodge, and a grove of large dead Engelmann spruce, killed by flooding in 1920 and 1921.

12. *Carnelian Creek Colonies.* Carnelian Creek is a good sized tributary of Tower Creek, which it joins about 4½ miles above Tower Fall. A single visit was made there in 1921, on September 6, when but a very limited time was available for exploration. The beavers were active here, and interesting works were noted, including a dam diverting the water from the stream into a series of ponds on a bench above the creek. On August 24, 1923, a trip was made to Carnelian Creek and new work of considerable interest was found. The supply of aspen is evidently largely depleted on that stream.

13. *Other Works Noted in the Yancey Region.* Below the old Yancey barns, where the north fork of Elk Creek comes tumbling through a narrow gorge to join the main stream, at the edge of the meadow the beavers once had a small pond—now completely silted up—formed by a dam which was interesting because of the extent of the arc it covered.

From the lower reaches of Slough Creek around to the west side of Buffalo Plateau, at the foot of the slope, are many old beaver works. But few of these are still occupied, and they exhibit all stages of decline to the beaver meadow stage. Some large ponds still persist, but the works are gone to decay, and practically all the accessible aspen groves were cut and pretty completely destroyed years ago.

Very recent minor works as well as old beaver cuttings and works were noted on Antelope, Amethyst, Oxbow and Blacktail Deer Creek in this general region, but these were not examined thoroughly.

14. *Lava Creek Roadside Colony.* This is an old colony 5½ miles east of Mammoth Hot Springs on the road to Tower Fall. It has always been a great attraction to tourists passing that way because of the large pond close beside the road, and the large lodge of typical beehive shape. The water supply is from Lava Creek which comes in from the south. Above this large pond is a series

Fig. 2 (5226). The Cooke City road and ravine near Yellowstone River Bridge, as seen from the slope of Junction Butte. Beaver works and dead aspens on right of road; aspen groves on left and at head of ravine. Aug. 26, 1921.

Fig. 3 (5225). Closer view of the Yellowstone Bridge beaver colony, showing ravine denuded of aspens by the beavers. Alders growing along run in foreground; dry sagebrush slope at right. Aug. 26, 1921.

Fig. 4 (5191). Yellowstone Bridge colony. Part of Pond No. 2, showing poles protecting entrance to burrows. These piles may in time become lodges, by the addition of material. Aug. 14, 1921.

Fig. 5 (5008). Yellowstone Bridge colony. Pond No. 6 from edge of the road, showing standing and fallen aspens. All of the trees are dead, but some young growth has started on the bank. July 13, 1921.

of smaller ones. The colony was active until 1923; but in the spring of that year the main dam was broken and the large pond partly drained. There seemed to be no activity at these works in August, 1923, but the beavers were reported to be busy again in 1924.

15. *Lava Creek Side-Gulch Colony.* In a steep rocky gulch about 3 miles east of Mammoth Hot Springs, below where the Tower Fall road crosses it in a sharp bend, is a series of ponds presenting some unusual features. The gulch is so narrow and steep that the dams are high in proportion to their lengths. The water supply apparently came from springs half way down the dry gulch. There was both old and new work here. The animals were using both aspen and Douglas fir for food; for the former was to be had only by dragging the cut logs and poles from the top of the steep, rough and stony slope down to the ponds.

16. *Beaver Lake Meadow.* One of the most noted and oldest beaver works in the Yellowstone Park is Beaver Lake with its remarkably long dam. It is situated beside the road from Mammoth Hot Springs to the Upper Geyser Basin, near Obsidian Cliff. The dam was carefully measured and found to be 1054 feet long. The former lake is practically all a meadow now, and the dam is destroyed where Obsidian Creek passes through it.

17. *Lewis River Fall Colony.* What constitutes the most remarkable tree cutting by beavers that has ever come to my notice is situated along the Lewis River below the falls, about a mile from Lewis Lake. Here were the tallest stumps I have ever seen—all lodgepole pines—and I suspect that one holds the record for height. They had all been cut several years previously, presumably when the snow was deep and crusted. Probably it was a case of cutting them for food or starving. No recent work was seen there.

DETAILED DESCRIPTION OF THE BEAVER COLONIES STUDIED

In the following detailed descriptions of the various beaver works surveyed and studied I have indicated for each case the year in which the data were gathered. Where a second examination was made in 1923, the supplementary notes follow, and frequent references are made to the photographs and maps of both seasons, for comparison and to make clear the rapid changes that are taking place. In consulting maps and illustrations, it is to be noted that the different photographic stations are indicated on the maps by original field numbers corresponding to the field photograph numbers (in parenthesis) in the figure legends.

YELLOWSTONE RIVER BRIDGE COLONY

Season of 1921. This series of beaver dams is situated on a small stream which empties into the Yellowstone River just below the river bridge on the Cooke City road, and about a mile from Camp Roosevelt (Map 3; Figs. 2, 3). It is the group of ponds which was most frequently visited by tourists staying at the Camp, many of whom went there in the evening to watch the beaver, which came out and went about their business, paying little or no attention to the interested observers lined up along the road above the ponds. It was a remarkably favorable place to observe the animals, which were frequently to be seen in broad daylight. The stream flows down a steep, narrow gulch, and is supplied from

swampy ground on the flat east of the road to Tower Fall; it also seems quite possible that seepage from Lost Creek may furnish a portion of the water. The road to Cooke City is built along the hillside on the southerly side of the gulch, and a number of the ponds are but a few feet below the road. This hillside has upon it a good growth of medium sized aspens, described in more detail below, while the steep hill on the north is largely devoid of trees; there are a few aspens on the lower slope of this, while there is much sagebrush (*Artemisia*) growing all over it. The vegetation along the stream consists of the common plants of the region, including the wild rose, fly honeysuckle, snowberry, wild geranium (both pink and white species), tall lungwort (*Mertensia*), cow parsnip, bedstraw (*Galium*), willow, an occasional choke cherry, Solomon's seal, and other flowers, as well as grasses. Below the ponds, nearer the river, alders grow somewhat abundantly.

My detailed examination of the ponds, including the survey, was made July 13, 14 and 15, though observations were made at various subsequent dates; and as a matter of fact, I visited these ponds more frequently than any other series studied in 1921, because of their accessibility and the opportunities for observation. I began with the lowest pond, which is about an eighth of a mile up from the river, in making my survey. Below this pond are old aspen stumps and cuttings in the gulch, but no dams, though an old pond indicated on the map can be detected. Some of these old stumps are six inches in diameter. Mr. M. P. Skinner, the former Park Naturalist, informs me that the beaver first began working in this ravine ten years ago, which is interesting because it gives some idea of the amount of work which these animals may do in a given time; it also indicates how long they may occupy a place. There are 18 ponds to which I gave numbers as I proceeded with my examinations, besides one or two which seemed too unimportant to be worth any special designation. These ponds and dams, with the exception of the three or four farthest up the ravine, are not of very recent construction, although most of them show late additions to the dams. They extend along the stream about 800 feet, and there is a difference of elevation between the highest and lowest dams of about 100 feet.

Many of the ponds have dead aspens standing or lying strewn in portions of them (Figs. 4, 5, 6). Some of these trees were cut by the beaver, while others have fallen naturally; and in some cases a considerable part of the pond is covered by a tangle of this fallen material. The dams all appear to be of essentially the same construction, mud and small sticks mingled together, with lengths of aspen lying crosswise the lower faces of the dams. This was the prevailing type of dam in all the colonies which I examined. Some of these sticks were old, while others were freshly cut pieces, from which the bark had been eaten. Placing these discarded sticks on the dam is the usual, if not the favorite, method of disposition. They vary in length from one to six feet, from two to four being the usual dimension.

The lowest pond (Map 3) is quite shallow, and has a number of old aspen stumps in it. The dam is about 4 feet high on the lower side in the stream channel, and measures 47 feet across the chord of the dam, which has a decided curve downstream. I found in this pond pieces of grass and other green plants lodged against the dam. This may have been the work of beaver or of the muskrat,

but it was the only indication of present occupancy which I saw. The end of the dam is against the north hillside, which forms that margin of the pond.

Pond No. 2 is also an old one, shallow in places, but it was inhabited by several beaver. I have seen one large one and two small ones in it at the same time. On the north side were a couple of irregular piles of sticks, a few feet apart, and there were holes, which the beaver were using, opening under these into the pond. These log piles protected the entrances to the burrows, and might in time be developed into bank lodges (Fig. 4). As in the preceding case there are fallen aspens and stumps in the pond. This dam was 54 feet across, with a slight curve downstream in one place, the remainder being quite straight. A beaver trail came down through the grass, from the dam above to the stream, and followed the latter for about eight feet to the pond.

Dam No. 3 has more than a right angle turn in it, which I estimated at 100°. One side measured 24 feet, the other 32. There were a few places on this dam where fresh mud appeared to have been applied recently.

Dams Nos. 4 and 5 are almost straight, and the ponds are quite rectangular. The former measured 64 feet across, and the latter 32. In the stream above No. 5 is a small old dam, which does not make a pond.

The dam at Pond No. 6 has a decided curve upstream, and is 60 feet around the arc. There was a trail from the end of the dam up to the bank and road.

Pond No. 7 is rather a large one (Fig. 6), the dam being 75 feet long with a slight curve downstream in the northerly third, while the shoreline along the hill is 37 feet. In the pond is a lodge, which is built partly on the bank, and projects into the pond 20 feet, with about 4 feet of the structure on the bank. It is 10 feet wide on the shoreline. The entrance appeared to be at the end in the pond and at the side close to the stream. Several beaver were living in this pond. At the beginning of the season we used to see two adults and three yearlings; late in August three kits made their appearance. The water was 2 feet deep at the outer end of the house, when measured July 13.

Pond No. 8 is a large one, with a dam 62 feet long, a slight curve downstream at the north end, and the side of the pond along the hill was 50 feet long. In the stream above it was Dam No. 9, a small one, quite unimportant. As we went upstream we found more freshly peeled sticks in the water and on the dams. These were from the aspens cut on the hill above the road, and in the ravine toward the upper end of the works.

Dam No. 10 was a straight one, 32 feet long, and setting at about right angles with the north hillside, along which the pond extended 27 feet. There was much dead wood lying about over this pond. Dam No. 11 has a deep curve downstream, one of the greatest of the whole series; and where the stream flows over it is 6 feet high on the lower face. Number 12 is a small shallow pond, apparently not of much importance. It lies off to one side of No. 11 and the stream. The water in No. 11 was 18 inches deep above the dam. Number 13 is another high dam, with a deep curve in the middle, downstream, and here the water was 2.7 feet deep. The dam was 60 feet long.

Number 14 is the highest dam of the whole series, averaging 4 to 6 feet high along the whole face, which is composed of aspen logs lying crosswise,

while many peeled sticks were lying in the bottom of the pond. The dam has a slight curve upstream. The water was about two feet deep above the dam. There were two holes under the bank on the north side, and trails leading up the hill. On the south bank of the pond is a lodge (Fig. 7), an irregularly shaped affair, 6.5 feet wide on the shoreline, extending up the bank 6 feet and into the pond 8 feet. The portion on the bank is of mud with small sticks; one fallen aspen is embedded lengthwise in it, while another projects from the shoreline diagonally up the bank and pointing downstream. There are also logs running out into the water from the lodge, some being trees which have fallen from natural causes, though the bark has been eaten off of some of them; others are trees which the beaver have cut. The entrance is probably at the edge of the bank under the mass of logs at that point; and there also seemed to be one at the water end of the lodge. The water was from 18 to 24 inches deep here. While once or twice a beaver was seen to enter this lodge I do not think it was regularly inhabited during the summer.

The remainder of the upper dams and ponds, Nos. 15, 16, 17 and 18, are small ones, and of importance only as waterways in passing up and down the ravine; the ponds are too small to be lived in. Dam No. 18 is of interest because of having the northerly end built against a large rock. The dam is 10 feet long, and 2 feet high on the lower side. It did not appear to be braced or secured in any manner against the rock, and I have little doubt that high water will readily take out this dam.

After the first examination in the middle of July no special attention was paid to this colony except occasional evening visits to watch the beaver. But on August 14 it was noted that the beaver were extending their activities up the ravine. Ten aspens were found to have been recently cut above the last dam and there was a trail up the hill to them. Where this came down to the stream the long grass was pulled and dragged downhill into the water so that it looked somewhat like a small dam. About opposite this place was a new small dam, not over 4 feet long; extended and raised, this would make a fair-sized little pond. A trail from below came up around the big rock at Dam No. 18 and joined the other trail about where the latter came into the gulch; a branch trail also went up over No. 18, by the rock. At this date there appeared to be more water in all the ponds.

The two trails leading up into the aspen timber above the road were more strongly marked than ever before (see Map 3). The upper trail is shown in figure 10. On this date twelve aspens had been cut near the lower trail. This trail measured 10 feet from the water's edge to the road, 29 feet across the road, and 100 feet to the end of the trail, above which no trees had been cut (Fig. 9). The boundaries of the aspen grove above the road were measured. I began beside the road 41 feet from the end of Dam No. 3; thence it was 200 feet up the hill to about the upper southeast corner of the tract. A few trees were left out on the eastern side of the line, and not more than one third of a space 150 feet wide here has trees on it. Thence it was 560 feet along the upper side of the grove. There are firs on the second hundred feet; and a swampy place with willows for about 50 feet below this east and west line extends over the third hundred feet. Aspens were scattered or wanting below the 300- to 400-foot section for some

distance down the slope. The 400-foot point is on the top of the hill, the slope of which is very steep here. On the upper trail I estimated the vertical angle to be at least 35 degrees.

At 500 feet along this line the upper trail was found, and three trees which had been cut early in the summer, after the leaves were out. The trail led over the top of the hill to the flat, and about 70 feet from the line was found a small natural pond, about 50 by 150 feet, with but little water in it. There were cat-tails in one corner and beaver tracks in the mud; at least one hole was found on the south side. I doubt, however, if any beaver were living there at the time of this examination, as the water was so low, and the tracks were not fresh. At the western end of this pond is a small aspen grove with stumps of various ages, some probably cut early last spring.

Along this same upper edge of the aspen grove, from the 200-foot point to the end of the line, aspens were very abundant on the hillside. It was 150 feet down the hill along the west side of the grove to the road. There were a few scattered aspens outside this line north and south down the hill, and also above the road to a point 350 feet above Dam No. 18. In the ravine there are aspens growing for nearly 400 feet above the same dam, after which willows appear. The densest growth of aspens is at 300 feet above Dam No. 18.

There seems to be an abundant supply of food trees in this grove above the road, combined with such trees as grow in the ravine itself; at least for the number of beaver likely to occupy these ponds for several years. The animals have pretty well cleaned out everything in the ravine below Dam No. 18, either by cutting the trees or killing them by flooding. There is one relation to be considered in connection with the beavers' utilization of the trees above the road as a food supply, and that is the constant exposure to their enemies after leaving the ponds and crossing the highway. As a matter of fact it was reported to me that one beaver had been killed near the lower trail during the summer of 1921 by some animal or animals. The bank immediately across the road is in most places so high and steep, as a result of artificial cutting to widen the road, that a beaver cannot ascend it easily; consequently their logging operations have to be carried on from the two trails as I have described, which are located at the places where the highway bank is most easily climbed. This circumstance renders the situation even more dangerous than otherwise, as it is easier for their enemies to see them when at work, and intercept them while going to and from the ponds. (See Figs. 7, 9.)

The trees along the ravine above the last dam are perhaps more favorably situated, especially if more small ponds are made, but if the beaver cannot use these, and finds it unsafe to use the trees on the hill, I see no alternative but the abandonment of this locality in the near future.

On September 5, I marked over three hundred stumps at this colony by pounding the end of a half-inch pipe into them, thus making a circle in the wood. All the recently cut stumps were thus marked, and most of the old ones, in order to make it possible for a future observer to recognize new work (see p. 174).

Season of 1922. This interesting colony was temporarily abandoned early in 1922, which is greatly to be deplored, as it was very favorably situated for

observation and study. In a letter to the author, Mr. M. P. Skinner states that most of the relatively few trees harvested that year were cut before the leaves came out, probably before the middle of May. Mr. Skinner has furnished me with a detailed record dated September 28, 1922, of all trees cut between September, 1921, and that date, as indicated by the unmarked stumps (see table on pp. 176–178). He says:

"The above record shows a total cut during the year of 135 aspens, 2 cottonwoods, and 21 alders. Some of these stumps recorded as aspens might have been cottonwoods instead, as this difference could not be told in the stump of such a small tree. The marking method used is far from permanent and in a few cases is already difficult to find.

"The trunks and even branches from stumps marked by Mr. Warren, were sometimes still lying on the ground untouched.

"Almost all the trees recorded above were cut in early spring before the trees had leaved out. Only one stump was fresh cut and that was a month old. Evidently the beavers have been feeding all summer on trees cut early and on small vegetation. No sign of storage for winter at any point yet. Beaver were about all summer but now no fresh sign anywhere, and some of the ponds drained. Both trails that cross the road lead to clumps of willows. Fresh bear tracks were found about the ponds, so this animal may be an enemy of the beaver."

Season of 1923. My first visit to these works in 1923 was on July 11, and it was then evident that the place was deserted. A few of the ponds were empty, and none was actually full. The lodge in Pond No. 7 looked rather dilapidated, and that in Pond No. 14 was in even worse condition. I examined it with some care on August 15, and found that the upstream side was undermined and washed away, and I could therefore make some examination of the interior. Unfortunately I had nothing to measure with, but the cavity did not extend more than six or eight feet into the bank. The interior appeared to be divided into two parts, separated by a large rock, and it was the upstream side which was the longer; the other was about two feet shorter. The longer part was about two feet wide and over a foot high. There was some shredded bark on the bottom, apparently the bedding. At the time of this last examination there were aspen twigs, with the leaves still on, in the water beside the lodge in this pond, as well as peeled twigs and some good-sized sticks. Two aspens had been felled on the hill above the road, and all the branches cut off and dragged down, but there was nothing to indicate that the pond was at that time occupied.

Pond No. 7 was full of water on this last date (August 15), and had much green algae growing in it. There seemed to be some fresh mud on the dam, though the trail over the latter did not show much sign of travel, and the algae in the pond showed no indication of disturbance by beavers having gone through it. There were rose bushes and peeled sticks in the water, though not as many as in No. 14. There were also small peeled sticks and willow twigs in Pond No. 2, where formerly three beavers lived. All the lower ponds were full.

One or two beavers seem to have had their headquarters along the Yellowstone River, near where the stream in this gulch empties. They were seen there by various people at different times, though I was not so fortunate myself. I have

Fig. 6 (5013). Yellowstone Bridge colony. The lodge in Pond No. 7, photographed from the dam, July 14, 1921. The lodgepole pine at left was cut by beaver a year later.

Fig. 7 (5019). Yellowstone Bridge colony. The lodge in edge of Pond No. 14, from the hillside on the north. The road runs along the cut bank above. July 14, 1921.

Fig. 8 (5185). Yellowstone Bridge colony. View down the ravine from the roadside opposite Dam No. 16. Note the lodge in Pond No. 14 in center foreground. Aug. 14, 1921.

Fig. 9 (5189). Yellowstone Bridge colony. The lower beaver trail crossing the highway to the aspen grove on the south hillside. Aug. 14, 1921.

little doubt that it was these animals which did the work I have mentioned, but do not think they intended to take up their residence at this place. Probably they were merely frequenting the locality during their casual wanderings up and down the river.

The abandonment of the colony near the Cooke City road was no doubt due to the near exhaustion of the food supply close to the stream, below the road, and the great danger involved in attempting to cut trees in the large grove on the hillside above the road, and conveying them across the highway to the ponds.

I examined this beaver stream farther up along the road, and above where the old road comes in from Yanceys, found a dam 7 or 8 feet long. Across the Cooke City road, on this same stream, were two other small dams, composed chiefly of small willow brush; no aspens were to be had there. According to Mr. A. G. Whitney, these latter dams, in this sluggish head of the brook, just where it emerges from a swampy area, were constructed early in 1922. Frequent signs of beavers feeding on the willow twigs were observed in July of that year. It is not likely that the beavers were inclined to actually start a colony there, for although good-sized ponds could have been made, no aspen was available, and the willows were small.

Seasons of 1924 and 1925. The following observations have been kindly furnished by Park Ranger John Bauman, in a letter dated November 14, 1925:

"In regard to the stream running along Cooke City Road near the Yellowstone Bridge, I have seen only two beaver that had lived in the old house on the bank. There were never any young in this vicinity at the time these two were there and now they are gone; where, I cannot say. My experience with these two, on or around December 10, 1924, is as follows: Saw a beaver crossing the road to cut quaking asp. He was, I would say, about 10 minutes cutting a tree 4 inches in diameter—which lodged. The beaver looked up at the tree and then began to make another cut about one foot from the bottom. This took about 10 minutes more, the beaver looking up at me every once in a while as he worked. After cutting away about one foot of the tree, it fell, and the beaver then brought this small piece across the road to a hole in the ice about 20 feet from where the tree was cut. In bringing the butt of the tree down a small slope and onto the road where I was on my horse, he passed to the rear of the horse, then became afraid, and dropping the piece of wood went into the hole. I rode on about 50 feet. The beaver then returned in about five minutes and took the piece of wood into the hole under the ice. I saw these beaver at work many times after this, but never on the dam. They would push out the wood they had taken the bark off of, and let it float away. These two beaver seem to have abandoned the spot, but there is still plenty of feed for them at this place. There were no beaver on the stream near Yellowstone Bridge this past summer. There is no new work there, in 1925."

The following interesting notes by Mr. M. P. Skinner, formerly Park Naturalist, show that some beaver returned to this colony site in October, 1925, since the last observations mentioned by Mr. Bauman, and they are evidently wintering there. Whether or not they were formerly members of the colony it is of course impossible to say. It would appear that the beaver are unable to resist the attraction of the fine grove of aspens on the hillside above the colony site, in spite of the danger of being intercepted by predatory animals.

Mr. Skinner says: "Mr. Bauman's information accords with my own observations, relative to the appearance of beaver near Yellowstone Bridge. What he says regarding the summer of 1925 is correct up to the time he left Tower Falls Station, which I believe was about September 18, but so far as I know Mr. Bauman had no opportunity for later observations there. As you will observe from my own notes, these state that the beaver did not appear this fall before October 11, and that their first appearance was between October 11 and 13. My notes are as follows:

"'May 29, 1925: Beaver cutting aspens (one or two trees cut) in gulch by Yellowstone River Bridge. One beaver dived as I passed by in automobile.' I passed by frequently during the summer, but saw no more of them until October.

"During the autumn of 1925 and even as late as October 11 I visited this section and particularly noted that there were no signs of beaver. But on October 13 I passed through the gulch and found they had repaired the dam to the pond where the house is, that they (probably two old beaver and no young) were then occupying the house, and had begun to cross the road to cut aspen. On October 24 I found the dam above the beaver house had been repaired also. Soon after the last date we had some cold, freezing weather (Oct. 25, plus 10°; Oct. 26, plus 5°; Oct. 27, minus 5°; Oct. 28, zero; Oct. 29, plus 10°; Oct. 30, plus 10°). Yet on October 30 I found the beaver had broken small round holes about eight inches in diameter in each pond, and had tramped two trails through the snow, and across the road to the aspen groves. I had seen these holes in the ice before and have wondered how they are made. It did not seem possible to me that the beaver could bite the ice, or break it from above. Furthermore, broken pieces of ice are on the ice above. In each case noticed, the hole has been made near a shore, a dam, or a beaver house, and it seems likely that the beaver gets a secure footing below and then heaves upwards with head or shoulders against the ice. From the great strength and development of beavers' shoulder muscles, they would be capable of breaking quite heavy ice."

UPPER LOST CREEK COLONY

Season of 1921. Lost Creek is the southernmost tributary of Elk Creek, having its source on the eastern slope of Prospect Peak, and flowing in a general northeasterly course past Camp Roosevelt and the Tower Fall Ranger Station, and thence northwesterly through the Yancey meadows, below which it joins Elk Creek. The series of beaver dams and ponds with which we have to deal is situated about half a mile above Camp Roosevelt, at an elevation of 6,800 to 7,000 feet (Map 4). Immediately above the Camp the stream runs in a deep box canyon with vertical walls, at the head of which is a fine waterfall 70 feet high (Fig. 11); and above this the valley again becomes more open and suitable for beaver This region was mapped and studied July 16 to 19 and subsequent visits were made on July 29 and August 31. Although an open valley, the part in which the dams are located is narrow with fairly steep hillsides on either hand. The floor of this broad ravine, where the beaver work is located, varies in width from less than 100 feet to about 150 feet, extending along the valley for nearly half a mile. Above the uppermost dam of the long series, the valley becomes still narrower, and about 1,000 feet above this point minor works were found on August 31.

Fig. 10 (5186). Yellowstone Bridge colony. The steep upper beaver trail through the aspens. View from the lower side of the road. Aug. 14, 1921.

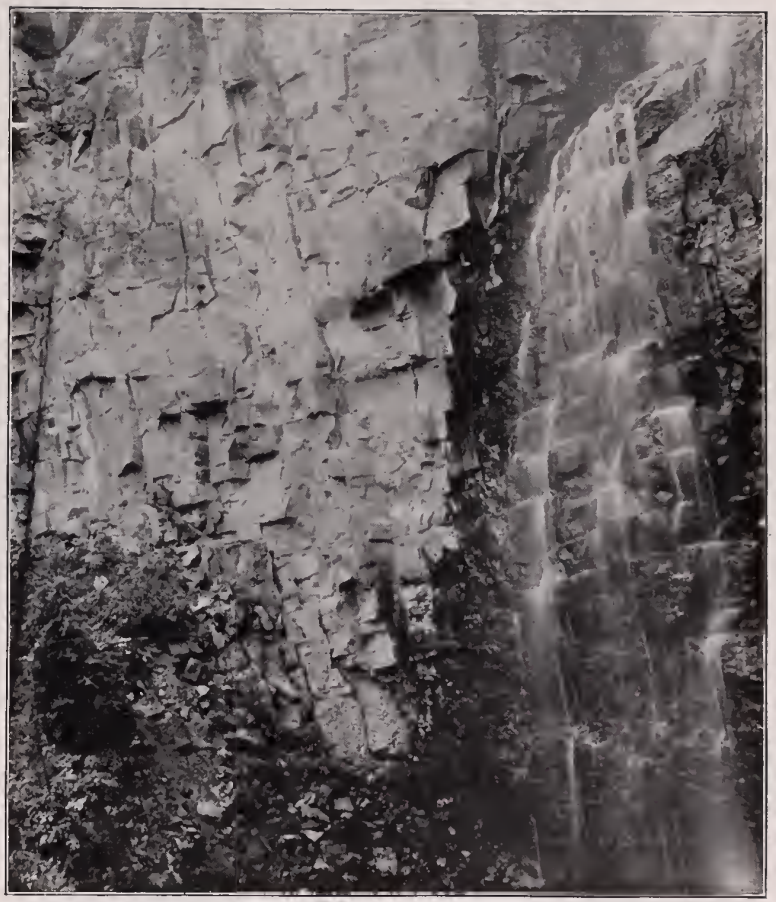

Fig. 11 (5252). Lost Creek Fall, about 70 feet high. The man is standing at top of the talus slope where a beaver skeleton was found in a deep cleft in the rocks. The creek at low-water stage. Sept. 2, 1921.

Fig. 12 (5030). Upper Lost Creek colony. The end of Dam No. 6, cut through by the stream and bent around to the east bank. July 16, 1921.

Fig. 13 (5029). Upper Lost Creek colony. The remains of a beaver lodge built against the bank, with roof supported by two poles. July 16, 1921.

The eastern slope has a quite heavy growth of lodgepole pines, from below the lowest dam up to the lowest occupied pond (Pond No. 10), and there the pines are replaced by aspens. On the western side the trees are mostly aspens, these being replaced on the top of the hill by lodgepole pines. In the creek bottom is a considerable growth of willows, all of the living ones being very small, although there are dead stems several feet high.

Altogether, this series consists of seventeen dams, most of which, however, were abandoned long ago. I began my examination at the lower end and numbered the dams consecutively as I went upstream. A detailed description of the works follows.

Dam No. 1 extended from the western side of the creek bottom across to the foot of the opposite hillside, the portion across the stream itself having been washed out. It is much overgrown with grass. On the left side of the creek the dam extends across the grassy ground to the foot of the hill; it is low, and I think not more than 2 feet above the general level anywhere. It is so old that the original height cannot be estimated, but doubtless the pond has been partially filled with silt and gravel. Along the lower part of the hillside from here up to about the third dam are old aspen stumps and small dead aspens. Just above this first dam at the eastern end gravel has been washed in; other than this the ground between Dam No. 1 and the next dam above is well covered with grasses of several species. The surface here is not level or comparatively smooth as in a typical beaver meadow, and for that matter this is the condition in all of the old ponds on Lost Creek. They are rather rough and hummocky, because the filling-in and leveling-off process was not completed when the dams broke and allowed the water to escape.

Dam No. 2 is quite high on both sides of the creek, which passes through at about one-third of the length from the western end. It is 68 feet long, with the upper side much overgrown with grass. There is also tall grass in the right side of the old pond, but on the left side much gravel has been washed up on the bank. Where the stream has cut through the dam a mass of sticks and mud is revealed. Above the dam, on the left bank, is a terrace against the hillside with an old lodge, the entrance to which was on the stream side, pointing a trifle upwards.

Dam No. 3 is about 300 feet above No. 2, and is so badly washed out, settled and overgrown with turf, that the line is hardly discernible. Willows from 2 to 4 feet high were growing near this dam.

Dam No. 4, about 100 feet long, is a much more conspicuous structure than any of the preceding ones. The stream here runs close against the hill on the eastern side of the gulch, and has broken through the dam, part of which still remains in the creek. This dam has many old sticks on the downstream face, and is grass-grown on the upper side, with low willows also growing upon it. It is now 3¼ feet high and over 3 feet thick where the stream cuts through. On the right bank, 50 feet above the dam, is the roof of a lodge which had been built against the bank. In constructing this lodge apparently advantage had been taken of the fact that a dead pine or spruce log had fallen diagonally along the bank with the upper end on the hillside, and the lower end hanging below the bank over the water, while another tree had fallen across

the butt end of the first one with the tip resting on the farther side of the creek. The mud and sticks forming the house had been piled on top of these crossed logs, and presumably all about below them; but now all material beneath the logs has been washed out, and part of the bank itself undermined and eroded away (Fig. 13). I am inclined to think that when the lodge was built the stream lay more to the west than at present, and its encroachment caused the destruction of the lodge. On the western side of the old pond much gravel has been washed in.

Dam No. 5 is apparently a very old one, so much settled down and overgrown with grass that one can hardly recognize it as a dam. It seems that the beaver may have occupied this valley at several different periods. Certainly the third and fifth dams, for example, appear to be much older than the fourth, although it may be possible that for some reason the latter was kept in use and repair longer than the others. I was unable to obtain information concerning any of this work on Lost Creek for previous years.

At Dam No. 6, the stream is on the west side of the ravine against the hill, with a cut bank 10 feet high just below. The dam has been cut through by the stream and the whole mass of débris apparently was swung around intact onto the easterly bank (Fig. 12). This affords an excellent example of the strength and compactness of some of these structures. This is a very solidly constructed dam, now heavily overgrown with grass, and with a good many small willows growing upon it. It is 4.2 feet high on the lower side, near the creek, and 6 feet thick at that point, including the sticks on the lower face. Near the east end a large lodge had been built against the dam; the water flows under this next to the dam, which possibly indicates that there were originally entrances on either side. There is, however, an entrance on the creek side at an angle of about forty-five degrees from the dam. The entrances to these old lodges always appeared to be at the present level of the ground in the old ponds.

The area between Dams No. 6 and No. 7 is grassy, with small willows growing on it. Dam No. 7 is a high one, 115 feet long, and as usual with old dams, broken through at the stream. On the western bank the stream has undercut and left the top layer of sticks hanging over. This dam was 4 feet high at that point. Farther up, on the west bank of the creek, is a gravel bar; on the eastern side is a flat with grass, small willows, seedling aspens, standing dead aspens, and one or two lodgepole pines, extending as far as Dam No. 9. All through this series of dams the stream bank is from 2 to 4 feet high.

Dam No 8 is an old washed-out structure, very difficult to trace on the eastern bank. The beaver are working on this bench and it has been somewhat overflowed. Dam No. 9 is on this bench and makes a small shallow pond, with much green algae floating on the water. This dam apparently utilizes portions of an older one which had been washed out and of which only traces are now left.

On the western side of the creek, between Dams No. 8 and No. 10, grass and willows are growing. It will not be long before there will be quite a dense growth of willow along the creek below Dam No. 10, as the bushes are spreading quite extensively over this area and their growth is very rapid.

Fig. 14 (5035). Upper Lost Creek. Pond No. 12, with beaver trails and slides on the steep east hillside. The slope has been completely denuded, but abundant young growth of aspen is springing up. July 16, 1921.

Fig. 15 (5048). Upper Lost Creek. Pond No. 12, showing its three lodges and the denuded aspen slope. The stumps indicate the upper limit of cutting, at the edge of the lodgepole pine forest. July 18, 1921.

Fig. 16 (5097). Upper Lost Creek. Ponds Nos. 11, 12 and 13, from the rock slide on the west bank, looking downstream. July 29, 1921.

Fig. 17 (6023). Upper Lost Creek. View downstream from nearly the same point as in Fig. 16, but two years later, showing drained ponds and exposed lodges and channels. July 17, 1923.

Dam No. 10 is the lowest dam where any really active beaver work is now going on. It is 110 feet long, with a curve or angle downstream 30 feet from the east end, and other lesser curves. At this angle the dam is only a few inches high, as the ground itself is high at this place, as well as flat. On August 31 the dam was 4.7 feet high at the creek, and fresh mud had been placed all along the top. Standing in the pond are dead aspens, evidently killed long ago. Below this dam, on the east hillside, are a number of quite freshly cut aspen stumps. Northeasterly from Dam No. 10, and only 14 feet from it, is a small dam but a few feet long, thus making a very small pond.

Above Dam No. 10 are two dams in a line, which I have called No. 11 (Fig. 16). I think very possibly they represent the utilization and reconstruction of an old dam. The area flooded by these is full of small willow bushes. When examined a second time, on August 31, there was much more water there, and the dam was well built up on the west end.

Dam No. 12 (Figs. 14, 15), which is the one forming the pond where the beaver appear to be living at present, is a high, solidly built affair, with the whole lower face covered with logs placed up and down rather than lengthwise of the dam, as is usual. It is about 130 feet long, with the ends against the hills on either side. It is at least 6 feet high at the highest place, and most of it is over 4 feet. Much fresh mud had been plastered on the top. In the pond were three lodges; two being good-sized structures, of the typical conical or beehive shape. The third lodge was a small one between the uppermost and the shore and appears to be built about a willow clump, the green willows showing through it. There were a number of quite freshly peeled sticks on top of the huts. Many trails led from Ponds No. 12 and No. 13 up the west hillside, and numerous aspens had been cut there (Figs. 14, 15, 16). Practically the whole area between these two dams was flooded.

Another long dam is No. 13, 150 feet in length, braced against the west hillside but not quite reaching the east, the western two-thirds being quite high, 3 to 4 feet, the remainder low, and holding the water back over the grassy land at the base of the east hillside. This latter portion was constructed of mud alone, no sticks being used.

Dam No. 14 is an old one, 83 feet long, and the pond is practically filled with earth and gravel which has been washed in (Fig. 23). In the pond is a lodgepole pine which had been cut and not used for any purpose.

Dam No. 15 is another old structure, the pond above which has been filled by the inwash of stones and gravel. The material filling Pond No. 14 is finer, containing much more mud. It is possible that the upper of these two dams served to retain the coarse materials, and permitted the finer to pass over and settle in the lower. There was an old lodge on the west bank between Dams Nos. 15 and 16. The latter is an old dam, washed out and undermined on the upper side. Between Nos. 15 and 16 are the almost indistinguishable remnants of another old dam. Number 17 is still another old and partly destroyed dam. There are two or three more ruins of former dams above this — about up to a point opposite the mouth of the ravine entering from the right — which are almost obliterated; and 100 to 150 yards farther up were some aspens cut within a year, the gnawed

bark being still quite fresh. Possibly they were cut the preceding autumn (1920). There are also old aspen stumps here.

The beaver did not appear to be cutting any trees at the time of the examination above Ponds Nos. 12 and 13 on the western side, nor above No. 13 on the eastern side. All the fresh cutting seemed to be on the east side above Pond No. 12, with a little, as already noted, below No. 10. I should judge that in another year all the available aspen will have been used.

When the last examination was made, August 31, all the beaver trails on both hillsides appeared to be much used, and yet not much, if any, fresh cutting was going on. It is not unlikely that the animals were coming up after such food as rose bushes and seedling aspens; they may also have been cutting into lengths the trees already felled. Some aspens had been cut high up on the west hillside after the leaves came out, for the withered foliage was still on the branches. On the east side, the farthest stump was 138 feet from the water, and on the west side 173 feet, measuring up the slope of the hill, this being in each case an angle of more than 30 degrees. These highest stumps were just below the lodgepole pines, which grow on the hills above the aspens (Fig. 15).

In the upper part of the site of Pond No. 13 some dead willows had been cut, also some small dead aspens there and on the hillside. Upon examination I found the sticks in the dam, apparently indicating that they had been cut with the definite purpose of using them as construction material.

As we were walking along the creek, on our way to work one morning, we noted at the edge of the water a round cake of mud, seemingly made fresh the night before; I could detect no odor of castoreum. It was 1.1 by 1.3 feet in diameter, and about 3 inches thick (Fig. 22). No doubt it was a "sign heap" made by a beaver, even though my sense of smell was not sufficiently acute to detect any odor that may have existed.

The series of dams and ponds which has just been described affords an excellent illustration of beaver works of various ages, from those which were abandoned so long ago that the ponds are either filled up or are in the process of being filled, and on the way to making meadows, to ponds and dams still occupied by the beavers or just recently built, where the harvesting of the crop of aspens on the hillsides is now in progress. No doubt this part of the stream has been abandoned and reoccupied more than once as the food supply has become exhausted, and then after a lapse of years a new crop of aspens has grown up and been used.

The dams highest and lowest on the stream appear to be the oldest, the pond sites of the former being the most filled up, presumably because they are situated where they stopped more of the material brought down by the water, or where the impact of the current was not strong enough to cut through the center of the dams. The lowermost pond sites are not likely to make real meadows, as their dams have all been broken through, the areas above them are no longer flooded, and therefore no more sediment settles there.

On August 31 an exploration of Lost Creek was made above the junction with the dry gulch, resulting in the discovery of considerable more beaver work, both old and new. About 200 yards above this junction was a new dam some 25 feet long, backing the water up for a space of 50 feet. This dam was of

Fig. 18 (6120). Upper Lost Creek. Pond No. 12 from the dam, showing the lodges and the channels in the bottom. Aug. 16, 1923.

Fig. 19 (6013). Upper Lost Creek. The north lodge in Pond No. 12, showing the wide entrance by which the photographer had access to the interior. July 14. 1923.

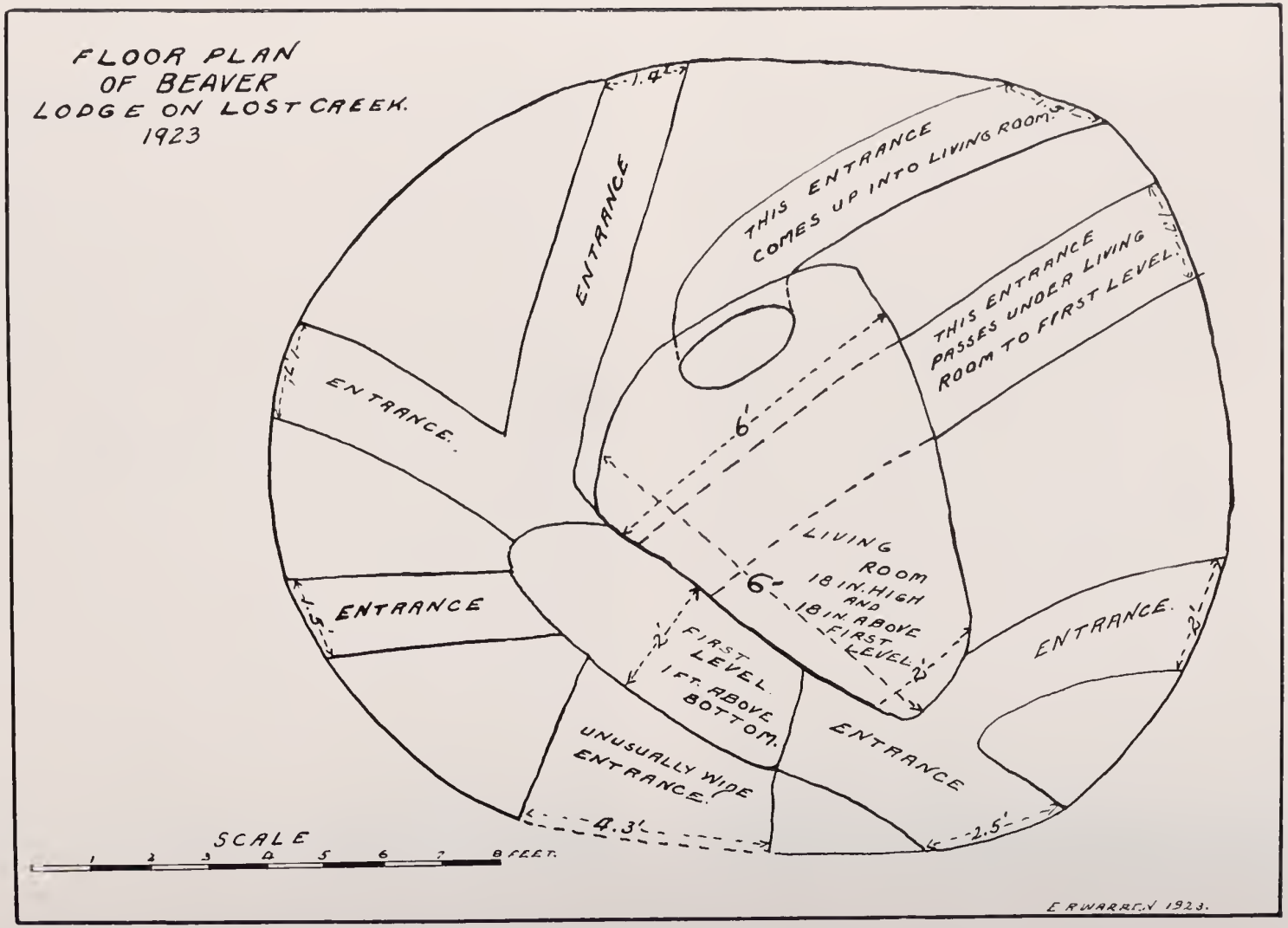

Fig. 20. Floor plan of beaver lodge in Pond No. 12, Upper Lost Creek colony. Aug. 16, 1923.

mud and grass dug from the bottom of the pond, and also had willow sticks, both dry and green, in it; it was about 2 feet high. About 100 feet above this was another dam, 50 feet or more long, and extending clear across the ravine, which is narrow along here. This likewise appears to be new, though there are some old sticks in it. It may possibly be a reconstruction of an old dam. There were broken pieces of a half-rotted pine or fir log, 8 to 12 inches in diameter, lying in the water and on the dam. One piece had been gnawed on the side by a beaver. They had cut a few aspens on the east side. There were none growing near the west side of this pond, though there were some at the lower pond, as well as on the east side at that place. Fifty feet above the second dam was a third, 30 feet long, with a considerable downstream curve; and thence it was about 30 feet up to the fourth, also much curved downstream, and about 20 feet long, backing the water up for 50 or 60 feet. At the upper end of the pond, on the east side, were about 20 aspens cut, and most of them had been used. There was a much-worn trail here. This is all new work, for there were no old stumps left by the previous occupants of the gulch.

Above this for some distance there were not many signs of beaver work, although one or two old stumps were noted. The valley was about 100 feet wide here. Then I came to what may have been the remains of an old dam, or may have been merely a jam of sticks. There were, however, beaver cuttings in it. Several hundred feet farther up, I found the ruins of a very old dam 40 feet long, which was the width of the ravine at this point. There were stumps of various ages on the west slope, some of this year's cutting, and some very old. The east slope was composed of slide rock. Fifty feet above was the remains of a dam nearly buried in vegetation. One hundred feet or more beyond this were old stumps on both sides of the ravine. The aspens here were 3 to 6 inches in diameter. Above these cuttings it looked as if there might have been another dam. All through this bottom are low willows and rank grass, with spruce or fir and a few pines. The conifers on the hills on either side are all pines. Above here there was a fork in the creek, but the east fork was now dry, therefore I followed the west.

Two or three hundred yards above the forks I came to another old filled-up dam, 30 feet long. The hillsides all along here were steep and rocky. There were large aspens and old stumps on the west slope near this dam. There was once a whole series of dams here, for four more ruins were noted in a space of a little more than 300 feet. The stumps are not so very old, only a few years, and the beavers had been in here in 1921 also, and cut aspens. Sixty feet above the last dam is an old lodge, built against a rock. About 150 to 200 yards above this place, possibly further, the ravine narrows, with spruce on either hand and in the ravine, and alders along the stream. There were no more signs of beaver, although I went on for some little distance.

While I found recent cuttings well up the ravine I am inclined to think they were made by wandering individuals, for I believe none were living this far up at the time of the examination, and that the resident beaver population was at the series of new ponds far below. No doubt in the past there have been beaver living on the upper part of the stream, but it has been a number of years since they were there. Some of the dams and cuttings are very old.

Season of 1923. This colony was again visited on July 14 and 17, and August 16, 1923. On the first date I descended to the creek at the lowest or No. 1 Dam, and thence walked upstream. A skunk was drinking at the stream when I reached there, and on slaking its thirst walked up the bank and entered an old beaver burrow. On the second date I walked downstream below this dam to see what food supplies there might be for the beavers. There are enough aspens near the creek for a small colony for a short time, and a fairly good site for a dam.

Going upstream there was no indication of the presence of beaver until on the west hillside, below Pond No. 10, were seen several quite recently felled aspens. Pond No. 10 was full of water and the dam in good shape. The two or three small ponds close by were also in good shape, and there were trails over several of the dams, indicating present occupancy of the ponds. The aspens on either side above these ponds, as well as above No. 12, had all been cut down.

I was much surprised when I came on top of Dam No. 12, and found the pond had been drained, except for the creek following a channel through it (Figs. 17, 18). Only two lodges stood there, though in 1921 there were three. I suspect that the third, which was but a small one, had been incorporated into the larger one which was close to it. This is the southernmost of the present two. The bottom of the pond was much intersected by the various ditches or channels. Old aspen stumps, one or two feet high, which had been cut by the beaver before the pond was made, were noted on the west side. There were fresh beaver tracks in the mud in various places in the pond. The trails on the hills on either hand were as well marked as ever.

The creek flowed directly under the south lodge, coming out in two places on the north side. This lodge was 18 feet in diameter, 7 feet high above the creek bottom, and 6 feet above the general bottom level. There was a freshly peeled stick 9 feet long on the top, and others 3 feet and longer. There were three entrances on the east side and one on the west. At least one entrance was in the pond bottom 6 feet out from the base of the lodge.

The north lodge (Fig. 19) presented a most unexpected opportunity to study the interior of a beaver's home. There were eight entrances to this, one of which was 42 inches wide, and opened directly into the interior. As the accompanying plan and photograph (Figs. 20, 21) show, there was a floor inside, a foot above the bottom level, 2 feet wide; and back of it and 18 inches higher, was the living room,—an irregularly shaped chamber 6 feet long, 2 to 4 feet wide, and 18 inches high. Some of the entrances were connected with one another, and three, besides the large opening, came directly to the first floor level. Another, on the opposite side of the house, passed directly under the chamber and opened onto the same level. The last, which was close to the one just mentioned, went under the room a short distance and then came up into it. One of the entrances to the room was 30 inches wide, the others varied from 1½ to 2 feet in width at their mouths.

The interior of the lodge showed very well its construction. The sticks were laid in every direction, well mixed with mud, and the ends were cut off on the inside to form the living room. These sticks varied in size from less than an inch up to more than 3 inches in diameter. Practically all these were

Fig. 21 (6123). Upper Lost Creek. Interior of north lodge, Pond No. 12, showing entrance and lower level of floor, and floor of chamber above. Aug. 16, 1923.

Fig. 22 (5050). Upper Lost Creek. A mud "sign heap" made by beaver at the edge of the stream. July 13, 1921.

Fig. 23 (5099). Upper Lost Creek. Pond No. 14, filled with inwash of gravel. View from below end of the rock slide. July 29, 1921.

Fig. 24 (6124). Upper Lost Creek. Pond No. 15, showing dams constructed on three sides of the pond instead of spanning the wide ravine. Aug. 16, 1923.

peeled sticks. I could find nothing in the way of bedding on the floor, merely a few peeled sticks less than the size of a lead pencil.

When a flashlight was fired in an attempt to photograph the interior of this lodge the smoke poured profusely from the opening in the top, indicating good ventilation, but it probably escaped much more readily than if the water had been up about the house so as to cut off the draft.

There was a channel under the lodge but no water flowing in it. The total height of the house above the stream bottom was 7 feet 6 inches, and 5 feet 6 inches above the general bottom level outside. It was about 13½ by 16½ feet in opposite diameters.

Pond No. 14 was full to the top of the dam, though it was shallow. There was a trail over the dam, and below it the grass and mud were trampled smooth by the beaver. A trail led from this pond up the east hillside to a grove of aspen, which was quite high above the pond, but nothing seemed to have been recently dragged down over it. About 20 feet north of the trail was a burrow in the bank which evidently was inhabited.

There were two more dams above No. 14, reconstructions of old ones. The second made a long, narrow pond; I think they were doing this work in 1921. There was one more dam above here at the right bank, and the pond had many small peeled twigs in it.

On August 16 I made my last visit to Lost Creek, and decided that the beaver were living in a pond above my old Dam No. 15, which they seem to have repaired. The pond had a roughly quadrangular shape, having dams on the northerly and easterly boundaries, the hill on the west, and the water was backed up against the next dam above (see Fig. 24). The old bank lodge which I had noticed in 1921 had been repaired somewhat and was evidently occupied.

There were two much used trails leading up the hill, one from near either end of the pond, and on the slope some good-sized aspens, 7 to 8 inches in diameter, had been cut. A little higher up, on a more level place 100 feet or more from the water, quite a good many stunted and small aspens had been cut, none being more than 4 inches through. The material from these had nearly all been removed and dragged down the very steep slope. There were enough trees here to carry a colony through the winter, though they were rather scattered.

On July 14 I visited the series of three ponds farther up the creek, and found they were still occupied, and I think larger than in 1921. The middle pond seemed to be the principal one, with a dam extending clear across the gulch — about 100 feet, and was almost square. Cutting had been done on the right bank above this pond. About 30 to 40 yards up the stream from the upper pond were a fair number of small aspens, mostly less than 3 inches through, and a little cutting had been done there. We passed by these ponds a month later (August 13), and everything appeared prosperous.

LOST LAKE COLONY

Season of 1921. Lost Lake is about half a mile west of Camp Roosevelt, and at an elevation of about 200 feet above that place. It is a long, narrow body of water lying in a ravine-like valley between low hills and has a northeast-southwest trend. Its length, including the marshes at either end, is two-thirds of a

mile but its greatest width does not exceed 300 feet. It is not shown on the U. S. Geological Survey topographical map of the Park. At the northeastern or lower end of the valley, is a low beaver dam about 90 feet long; and a few feet beyond this dam is a cliff over which trickles a little water, making its way down a gulch to Lost Creek. The water in the lake is supplied by springs. About 800 feet at either end of the lake is grown up with grass (Figs. 25, 28) and the central portion is deep, open water. All of this open water is bordered with grass to various distances from the shoreline, and beyond this grass is a zone of yellow water lilies, which also grow at either end of the open water out to a maximum depth of 10 feet. The width covered by the grass and lilies is much greater on the northwestern side of the lake than on the southeastern, due possibly to the fact that the hill on the latter side is considerably the higher and therefore shades that shore more, and the slope drops off more abruptly under water. By the northwest shore of the lake (Figs. 25, 26) is a lodge 15 by 20 feet wide and 4 feet high above the water, built of turf and mud, very dry at the time of the examination (August 11), and with many small sticks on top of the mud. There was a landing place on the southwest side of the lodge. We saw a beaver swimming near the lodge at ten o'clock in the morning.

In a number of places along the shore are willows (Fig. 26), the taller stems dead but with new green shoots coming up from the roots. The ground along the lower northwestern slope is mostly quite open and grassy for a short way up the hillside, with sagebrush above (Fig. 27). For a few hundred feet on that side, along the edge of the marshy outlet, there is Douglas fir and lodgepole pine forest, mainly the former. On the southeastern side the slope is much higher and steeper, with two areas of slide rock extending down into the lake. Otherwise it has a good growth of fir extending about to the lower end of the open water, beyond which pines replace the firs. The ground at the southwest end is open meadow for a considerable distance, beyond which is a hill with conifers and aspens.

Here and there along shore, on either side, are old aspen stumps, but it is evident that there have never been many aspens here; at present there are but one or two living trees by the lake. A few trees had been cut recently, to the northeast of the lake, but it seems probable that the beaver are living mainly, if not entirely upon the roots of the yellow water lilies which are so abundant in the lake. At the grassy upper end occasional trails came ashore through the marsh and at one there were noted a lot of the flower heads of a species of groundsel which is common in the region.

About midway across the grassy upper portion, at the shore, is what may be the beginning of a lodge, as grass and mud were heaped in and about a clump of willows, and the channel traversed by the beaver seemed to come quite close here. There is an open channel through both the grassy ends of the lake, but it was impossible to tell if there was any current in either.

The dam appears to be of considerable age. Slight repairs had recently been made on it.

Soundings were made in the narrower eastern half of the lake by Prof. A. G. Whitney and Dr. R. A. Muttkowski, late in August, and the rather surprising

Fig. 25 (5174). Lost Lake, showing the beaver lodge (at right) and character of the shores,— meadow at west end, and rock slide with Engelmann spruce on south hillside. A drowned lodgepole pine in foreground. Aug. 11, 1921.

Fig. 26 (5173). Lost Lake. Close-up view of the beaver lodge, and zones of yellow water lilies and drowned willows in marsh. Spruce forest beyond lake. Aug. 11, 1921.

Fig. 27 (5175). Lost Lake, looking toward outlet from rock slide at southwest corner. The beaver lodge is at left, with sagebrush slope above. Aug. 11, 1921.

Fig. 28 (5152). Lost Lake. View across flooded marsh toward lake and Prospect Peak, from low dam at outlet. Note Engelmann spruce and willows killed by flooding. Aug. 11, 1921.

depth of 48 feet was obtained in one place. It was found that through the open portion the bottom pitched steeply toward the center from either side, indicating a considerable natural depression there. However, when one takes into consideration the distance from the shore to the middle of the widest point, 150 feet, this maximum depth of 48 feet, making an angle of about 18 degrees from the horizontal, does not indicate a very steep slope for a mountain lake. It is evident that the beavers, by constructing the dam, are responsible for the drowning of a fringe of Engelmann spruce along the southeast margin, and to some degree for the lake in its present form. They are also giving an excellent illustration of the way in which a beaver meadow is formed, for in a comparatively short time both swampy ends will become meadows, though it would take a very long time to fill the deep central portion with the small amount of sediment being brought in from the margins.

Season of 1923. Lost Lake was visited on July 17 and August 11. On the first date I found on the western shore of the lake the remains of a beaver which had been killed that spring. There was nothing to indicate what sort of animal had done the killing, but very likely it was a coyote. I secured the skull, which was perfect except for missing nasal bones. I did not find the lower jaw.

The Park authorities, in attempting to reduce the mosquitoes, had cut the low dam early in the spring, lowering the water about a foot. It would take much more than that to do away with the marsh and prevent the breeding of mosquitoes there.

On the second visit (August 11) I found in the marsh grass on the west side of the lake, between the lilies and the shore, an irregular open pool, with mud thrown up on the sides. It was 3 feet wide by 6 long. Nearer the open lake there was a similar smaller pool, from which a trail led to the deep water. There was also a trail from the hole to the land, and trails through the grass at other places. The water side of the lodge had fresh mud and weeds from the lake bottom placed on its top.

There were places where the beavers had cut the yellow lilies. I saw bitten-off ends of stems in the water and short pieces on shore. One day in July Mr. E. J. Sawyer, accompanied by a group of tourists, observed a beaver swimming in the lake and carrying in its mouth a large lily pad held over its head in the manner of an umbrella. It swam to the lodge, where it dove and evidently carried the leaf inside.

On the northwest side where the large Douglas fir forest comes down near the marshy shore, at the outlet end of the lake, the beavers had begun to cut some of the small firs in 1922, stripping the limbs of their bark for food. One of these fresh cuttings, collected as a specimen by Mr. Whitney, measures 5 feet in length, with a diameter of about 2 inches at the base and 1½ inches at the top. It had grown in the shade of large Douglas firs, about 10 feet up on the dry slope, and the growth rings show it to have been over 68 years old. After cutting the sapling, the beaver evidently leisurely gnawed off the bark from end to end, and nearly two-thirds around the stick, but not turning it over to get at the under side. The beavers had not yet begun felling the larger firs

by 1923, as they had at Crescent Hill Pond and elsewhere. On the opposite shore, back a short way from the dam a few aspen saplings still remain on the level ground scattered among the lodgepole pines, and here an occasional aspen is still being harvested.

THE YANCEY MEADOWS

Season of 1921. Along Lost Creek, from below Camp Roosevelt to the junction of the stream with Elk Creek, is an extensive meadow or series of meadows, a mile or more in length (see Figs. 29, 30). Figures 31 and 32 show the uppermost of these meadows just below where the highway crosses Lost Creek. This is divided into two portions by the closing in of the hills on either side about a third of the distance from the southerly end of the tract, leaving but a narrow gap. The southern portion is quite marshy and wet under foot in many places, and a considerable part of the area is covered with willows, the taller stems of which are dead, with new growth coming up from the roots. Some of the ground is sufficiently drained for hay to be cut, and grasses common to the dry ground grow there (Fig. 32). The wetter portions are covered with coarse marsh grasses (Fig. 33). A careful examination of this area above the narrows failed to disclose any indications of beaver dams, though it is probable that they once existed and were obliterated many years ago.

There are, however, in the narrows above mentioned, several old dams, unused for years. (These are the Seton dams, referred to again on page 60.) The uppermost one is the best preserved, and appears to have been built largely of mud and sod; only a few sticks can be seen in the cross section exposed by the creek (Figs. 33, 35). It is 10 feet or more wide at the base; the top is about 5 feet above the present water level where the stream breaks through it, and 3½ feet above the ground level on the upper side. The creek runs near the east side of the narrows. To the right of the stream the dam extends 22 paces to the foot of the slope; to the left it extends 80 paces to the base of the west slope; and the creek itself is 6 feet wide. The top of the portion on the right bank of the creek is quite bare of grass, with which it is elsewhere covered. The dam extends from the base of one hill across to the base of the other, curving somewhat upstream near the right (east) end. The left end curves downstream and is 2 feet high on the upper side.

Beside the stream, and 150 feet above the dam, are the ruins of an old lodge measuring 26 feet in diameter (Figs. 36, 37). It is so old that it has entirely caved in and flattened out. It was evidently once well covered on the top with sticks; but judging from the decayed condition of these it has been abandoned for many years. Below the main dam 125 feet is the remains of another dam, lower, and 50 or 60 feet shorter, not at all well defined on the left side of the creek, which is here more nearly in the middle of the meadow. Like the one above, it appears to have been mostly mud and sod, as but few sticks are visible in the cross section. Below this point the faint outlines of two more dams may be observed, but they have been nearly obliterated by age. It is of course very probable that there were many sticks in the construction of all of these dams and that they have mostly disappeared completely from decay.

Fig. 29 (6087). The Yancey meadows. View northwest toward ranch buildings from point where the old road crosses Lost Creek. Aug. 6, 1923.

Fig. 30 (6085). The Yancey meadows from the rock slide above the ranch buildings, looking southeast. The South Fork of Elk Creek comes in at right. Aug. 6, 1923.

Fig. 31 (5155). View northwest toward Yanceys from terrace above Camp Roosevelt. Park highway and sagebrush flat in center, and extensive meadows with willow thickets along Lost Creek, beyond. Aug. 13, 1921.

Fig. 32 (5200). Upper Yancey beaver meadow from hill on west, looking up Lost Creek. Hay had just been cut above the old dam. Aug. 17, 1921.

Below the narrows the valley widens extensively and is here a broad, perfectly level meadow where much hay is annually cut for feeding the rangers' horses and the elk in winter (Figs. 1, 29, 30). Besides the native grasses, timothy and redtop and perhaps other cultivated grasses have been sown here. Some of the land is still wet enough for the marsh grass to persist, but proportionately there is not nearly so much of this as in the meadow above. The stream flows near the eastern side of the tract. I examined the ground carefully as I walked along the stream, but no signs of beaver work were to be seen until well down toward the lower end, where I found the remains of a lodge, and possibly of a dam. The creek divides into two channels here, and on the ground between these was the lodge. It was apparently very irregular in shape and well covered with sticks. The greatest diameter, 22 feet, is across the creek, and the width is 17 feet. Below the lodge, in the western channel, I could see sticks projecting from the bank on both sides and also lying on the shore. There was nothing of the sort in the other channel. There are many old willow stumps here, some cut close to the ground, others 2 to 3 feet high (Fig. 38). There were no aspens growing near by.

About 125 feet downstream, on the left bank of the creek, is another old lodge, 10 feet in diameter. The interior has all collapsed and been washed out. Farther down, about 175 feet, are the remains of a dam, of mud and sod, 4 feet high, at the creek. On the left bank it quickly diminishes in height; it has a decided curve down the valley. Below the dam, on the right side of the creek, were a lot of small sticks which may have been washed down from the dam. There were likewise some sticks on the lower side of the dam and also what looked like a covering of sticks over the entrance of a burrow. There was also some beaver-cut driftwood on the left bank.

Two hundred feet below this was still another old dam, much gone to ruin. Either this extended only from the left bank to the rocky hillside at the right, or else it has been completely filled up in the meadow; the portion on the right bank is about 30 feet long. Still farther down the stream are the sticks of an ancient dam projecting from the bank, but the dam itself is now no longer visible above the general level of the ground.

Mr. M. P. Skinner has very kindly given me valuable information concerning these meadows. He first came to the Park 30 years ago, and at that time the beaver were living on Lost Creek, where the lower meadow is now, and none were living on Elk Creek, though there were old dams and stumps along both branches. There was an extensive series of dams and ponds on Lost Creek which were examined and mapped by Ernest Thompson Seton in 1897, and which he has very fully described and illustrated (Seton '09, Vol. 1, p. 456). The ruins of these various dams which I have described above are doubtless the remains of those observed by both Seton and Skinner.

Mr. Skinner also tells me that about 1903–4 the beaver on Lost Creek began to decrease, and a colony again formed on Elk Creek. It seems most probable that the reason for the abandonment of the Lost Creek ponds was the exhaustion of the main food supply of aspens and willows.

The cutting of hay on these meadows has evidently been going on for several years, but even if it had only just begun it would seem remarkable if

in the space of 18 years all these ponds should have been filled up or drained and the dams largely obliterated.

Mr. Skinner remarks in a letter to the author that "curiously and perhaps significantly" the forming of a colony on the North Fork of Elk Creek in 1903–4 coincides with the abandonment of the old road up that branch of Elk Creek and the opening of the present tourist highway, his theory being that the traffic along the road on Elk Creek and possibly trapping may have driven the beaver away from there previously. Be that as it may, the beaver have remained on upper Elk Creek ever since their return, though moving about up or down both branches of the stream, and latterly toward the heads of all tributaries.

Along Elk Creek, below the Yancey place, are several almost obliterated dams, at intervals along the meadow. Mr. Skinner informs me that these are very old, that they were there when he came to the Park in 1898, and were abandoned at about that time. He also states that some of the dams on the North Fork of Elk Creek are very old.

Many generations of beaver must have been concerned in the making of these extensive areas of meadow land. It is almost useless to speculate upon the character of the ground before the first beaver dam was built, and to attempt to reconstruct the succession of changes. Perhaps the whole valley was much deeper and naturally therefore narrower at the bottom than at present, and the beaver pioneers built but small dams at first, their successors gradually increasing them as time went on, and the ponds slowly filling up with silt. Not unlikely, indeed, most probably, the place may have been abandoned many times for various reasons and later reoccupied. The repeated exhaustion of the food supply would cause this. If the number of existing aspen stumps is any criterion, there were very few of these trees here close to the meadows at any time and the beaver must have subsisted largely on aspen brought from farther up the slopes, supplemented by willows from the bottoms, together with such herbaceous plants as they may have been able to obtain during the summer months.

In connection with my study of the meadows the following grasses and herbaceous plants were collected on the upper portion of Lost Creek and kindly identified by Mrs. Agnes Chase, Assistant Agrostologist, Bureau of Plant Industry, U. S. Department of Agriculture:

Carex festivalis Mackenzie, probably. Sedge.
Juncoides parviflorum (Ehrh.) Coville. Rush.
Poa crocata Michx. Blue grass, meadow grass, spear grass.
Bromus richardsoni Link. Brome grass.
Agropyrum tenerum Vasey. Wheat grass.
Calamagrostis canadensis (Michx.) Beauv. Blue-joint grass, reed grass.
Equisetum arvense L. Horsetail.

Season of 1923. In 1897, when Ernest Thompson Seton was in the Yellowstone, he made a study and survey of certain beaver dams and ponds on Lost Creek, above Yanceys, which he published, with a map and sketches, in his Life Histories of Northern Animals (Seton '09). In 1921, though aware of this, I did not have his data at hand for reference.

Fig. 33 (5198). Upper Yancey beaver meadow and the longest of the old dams, looking up Lost Creek. The creek now flows through the break shown in the dam. Aug. 16, 1921.

Fig. 34 (6075). The present condition of the Yancey beaver ponds studied by Seton in 1897. View from west, showing long upper dam and creek. The south branch of old canal runs close to the man at right. Aug. 6, 1923.

Fig. 35 (6074). View of the beaver works studied by Seton, from the east. Upper dam at left; second dam, where the man stands, at right. Note small willow clumps in meadow, some of which were being cut by beaver. Aug. 6, 1923.

Fig. 36 (6073). A portion of the main pond site and ruins of old lodge, Aug. 6, 1923. Seton's sketches show the food supply in 1897 to have been a grove of aspens (since destroyed) on the bench above the rock slide.

Fig. 37 (5197). Ruins of old lodge in upper Yancey beaver meadow. Sagebrush hills at left. Aug. 16, 1921. (See also Fig. 36.)

Fig. 38 (5203). Stumps of willows cut by beavers in lower Yancey meadow, just above the junction of Lost Creek with South Fork of Elk Creek. Very springy ground, covered with marsh grasses. Aug. 17, 1921.

In 1923, however, with a copy of the map and the sketches, I had no difficulty in locating the place, which was at the narrowest part of the Lost Creek valley between two rocky slopes. The present condition of this I have already described. Seton's upper dam, 300 feet long, is plainly to be seen, and is the most prominent one there; and the lodge, which was in the pond above, still exists, though a crumbling ruin in the meadow. He made out the pond to be 250 yards long and 80 wide.

The next dam below is readily seen, and we found the canal at the western end of this dam to be distinct and exactly as Seton mapped and sketched it, dividing into two branches near the foot of the hill. I thought in 1921 that the bank below the canal was part of the main dam, and it may just as well be considered such, for it is really an extension of the dam. (See Fig. 34.)

Below this, while a few of the numerous dams found and sketched by Seton can still be traced, most have practically disappeared. According to his map, it was 954 feet from the second dam to the lower end of the series. His fourth dam was apparently considerably extended after he made the survey. He indicates it as being in two parts, each 10 feet long. The present ruins extend from the creek almost to the foot of the hill, 44 feet. On the west side of the stream there was a canal above the dam. The ground rises so fast on this side that probably there was not much of a pond there, nor is the dam as noticeable as on the east side. The canal was 18 inches deep toward the west end, 12 inches deep nearer the stream, and 18 inches wide.

Seton gives the stream measurements as 18 inches wide and 3 inches deep, and the flow as 1½ miles an hour. He states that "the source of all the water was a spring or springs in the marsh above." The brook is now somewhat larger apparently, although it varies according to the dryness of the season. It is in fact Lost Creek itself, the source of which is far back on the slopes of Prospect Mountain. Possibly Lost Creek has been diverted to the Yancey Meadows from its former drainage which seems to have been partly into the small stream entering the river near the Yellowstone Bridge, largely by seepage underground. Mr. M. P. Skinner is of the opinion that the soldiers formerly in charge of the Park diverted Lost Creek to flow past the Tower Fall Ranger Station, subsequent to Seton's 1897 observations. If this is the case the diversion occurred probably in 1907, the date of the removal of the ranger station to its present site. What effect such diversion may have had on the beaver operations in either stream is an interesting question. The contour lines on the topographic map of the Park give no clue by means of which this problem can be solved, for they show nothing which indicates any depression through which water would flow toward either the Yancey Meadows or to the Yellowstone River at the bridge.

SOUTH FORK OF ELK CREEK, AT YANCEYS

Season of 1921. On the South Fork of Elk Creek, but a short distance above the old Yancey cabin, is a small group of ponds, three of which are formed by dams of some length, though the ponds themselves are of no great width up-and-down the stream. They are situated on ground which is quite

flat and extend in an east and west direction, with a gentle upward slope to the south and a steeper, heavily forested slope on the north. This land is quite wet and swampy, with tall grass and some small willows. The little stream which I have called the South Fork comes in from the southeast, though its source is to the southwest, beyond the Petrified Tree Road. There are low willows along its course near these works and dense spruce encroaches on the flat at the north margin. Another smaller rivulet parallels it a little to the east and enters Elk Creek below the Yancey cabins. Near the ponds the land is open on the east until opposite the eastern end of the third or uppermost dam (Map 6), where there is a rather sparse growth of aspens not far distant, and above these, lodgepole pine woods. Westerly from the ponds the woods comprise spruce on the flat and fir and some pine, principally the former, above, and there are a few aspens near the end of the canal. Directly south, above the swampy ground, upstream, are conifers and aspens. I could not discover that the beaver had as yet made any use of these aspens; but they will do so if they can extend their works farther upstream.

The three long dams are all old structures. The first, which is about 200 feet long, and very crooked, forms a pond of very irregular shape and width, from 10 to 80 feet. The eastern end of this dam is very flat, and most of the sticks all along the face are old. There is much grass growing on the lower side, and more growing on the mud on top. The height of the lower side varies from 1 to 4 feet. Several tall dead Engelmann spruce trees are standing in the pond, besides smaller ones; some, their foothold weakened by flooding, have fallen, and there are also uprooted alders. One large spruce has fallen on the southwestern side of the pond, elevating the roots and adhering earth perpendicularly, and taking with it a clump of good sized alders which were growing beside the spruce. There is a lodge on the upper side of the pond, with one end against or in the second dam (Fig. 39). This lodge is rather elongated in shape, the opposite diameters 7 by 10 feet. It was well plastered with mud when examined, though this was old, and old sticks were lying on the mud. Near the western end of this dam is a small dam which branches off from it, forming a separate small pond. From this pond a canal extends northwesterly 104 feet (Figs. 41, 42). For most of its length it is from 4 to 6 feet wide, and 27 inches deep. It has been excavated by the beaver, and the material obtained in doing this work was thrown up on the lower or northeast side to retain the water, as the surface slopes slightly in that direction. The water is supplied from the small pond. Near the pond the bank of the canal curves so that the water is here 15 feet wide. From the end of the canal a trail runs northwesterly. There are aspens and some fresh cuttings here. Near the end of the ditch was an aspen tree 2½ inches in diameter suspended upright in a spruce. It had been cut by beaver, but the only stump near was one around on nearly the opposite side of the spruce tree.

Dam No. 2 was about 200 feet long, while the pond was narrow, with the open water but 5 to 15 feet in width, and above, the ground was very swampy and springy and overgrown with grass. Dams Nos. 1 and 2 diverge greatly; the northwest end of No. 2 is close to No. 1, but the southeast end is about 100 feet distant from the corresponding end of No. 1. On September 4

Pond No. 2 was found to be drained entirely. There was no break in the dam, so possibly a hole had been forced through at the bottom. The pond, when drained, was seen to be not much more than a rather wide ditch.

Dams Nos. 2 and 3, about 60 feet apart, are more nearly parallel and similar, No. 3 being over 160 feet in length, with a narrow pond behind it. The lower face varied in height from 18 to 36 inches. Much of the material used in construction was mud and small sticks, and fresh mud had been added to the top (Fig. 40). The open water in the pond was irregular in extent, and measured 20 feet at its greatest width. Above, the ground is swampy and slopes gently up to dryer ground. There were some small dead spruces in the northwest end of this pond. At the southeast end of the pond a ditch 12 inches wide and 18 inches deep entered it, and extended 48 feet southeasterly to a small dam. At 27 feet from the pond the deep portion of the ditch ended, and a shallow run with water flowing in it continued to the dam. The dam at the outer end extended 20 feet east from the ditch, and the pond above was only 6 feet wide. A trail and a mere trickle of water led into this. Above, there is a swampy stretch with much brush, including willows and small spruces. Outside, on the dryer ground are lodgepole pines with some aspens, and a little cutting had been done here. This detailed examination was made on August 3. On August 10 another visit was made to this spot, and a new ditch was found coming into the old one, about 5 feet above the pond, with a new dam 10 feet long across it, 5 feet above the old ditch. Then there was a ditch or old channel for 15 feet, then another 10-foot dam, at least 18 inches above the water level in the ditch below. This dam was of mud and sticks, and freshly cut green willow twigs were on the top. On September 4 all these small dams appeared to have been extended and built higher, and there was another dam above the second one on the new ditch; also trails leading down from along the watercourse above.

Unless the beaver inhabiting these works were living in the lodge they must have had holes extending back some distance from the upper pond under the gently sloping ground to the southwest. This is covered with a good stand of large Engelmann spruce. The fact that the first and third ponds appeared to be in active use at the time of the last visit, while the second was drained, would seem to indicate that these two were the ones which the beaver intended to occupy during the winter, though there was as yet no sign of their storing food.

Season of 1923. This colony was examined on the ninth of July, and the changes noted were comparatively small. The lowest pond, No. 1, while fairly full of water, did not appear to be in use by the beaver. The water in the pond was largely covered with a thick layer of algae, and this showed no indications of the passage of beaver through it, while the trails over the dam did not seem to have been used lately. Many of the dead trees which formerly stood in the pond had been cut down with an axe and the logs hauled away. Nor did the lodge appear to be inhabited.

In the little pond at the head of the canal were a few small peeled sticks and an alder leaning over the water had had considerable bark gnawed off this spring, though the tree itself had apparently been cut a year ago. The canal was dry.

Fig. 39 (5106). Beaver works on South Fork of Elk Creek, near Yanceys. Pond No. 1, showing lodge (at left), with standing and wind-thrown dead spruce killed by flooding. Aug. 2, 1921.

Fig. 40 (5107). South Fork of Elk Creek. Pond No. 3, the uppermost of the series. The new upper canal extends into meadow from left corner. The live Engelmann spruce trees in the pond were very recently submerged. Aug. 2, 1921.

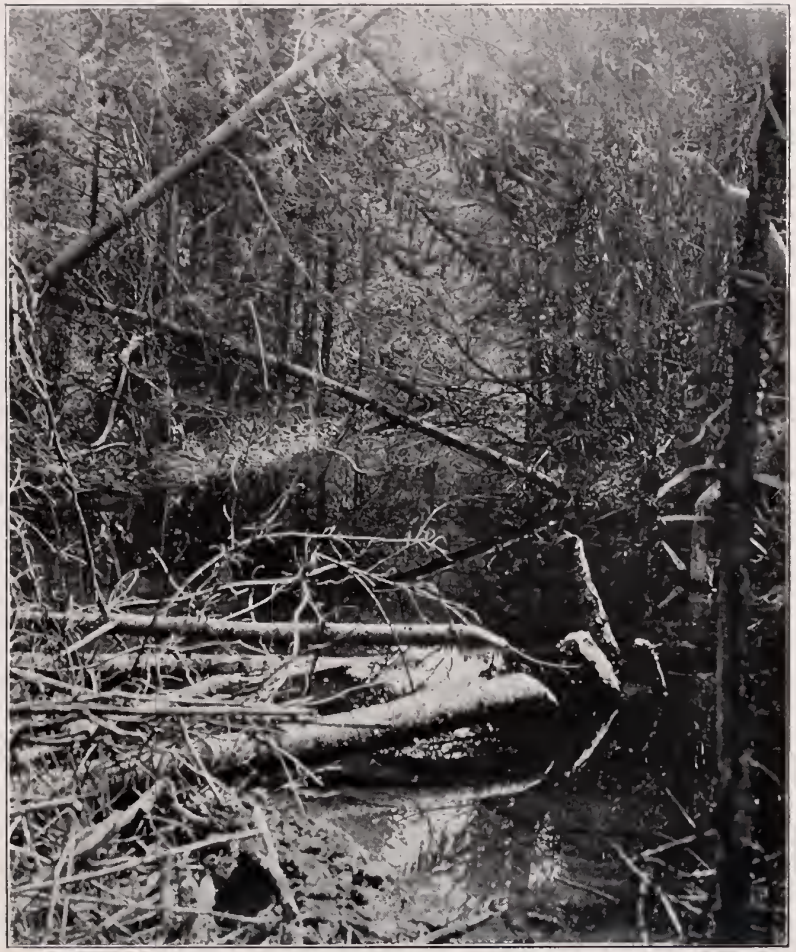

Fig. 41 (5108). South Fork of Elk Creek. The lower canal, as it appears from the west end of Dam No. 2. Note Engelmann spruce trees, cut by the beaver. Aug. 2, 1921.

Fig. 42 (5109). South Fork of Elk Creek. The outer end of the lower canal, looking southwest toward the ponds. The forest is of dense spruce and the ground is very boggy. Aug. 2, 1921.

Pond No. 2 had water in it and I saw beaver tracks in the mud at the west end. When last seen in September, 1921, this pond had been drained, though both the ponds above and below were full at that time.

Pond No. 3 was full, and the water at the east end was 27 inches deep at two different places, and at about the middle of the dam it was 3 feet deep. Toward the westerly end of the dam a good trail led down into the outlet, and directly opposite this, on the bank, was a lodge, built since September, 1921. There was considerable algae in this pond, but not so much as in No. 1. The beaver were evidently living here at this time. The canals and small ponds at the easterly end were full and seemed to be in use. On the south shore two or three trails led up the gentle slope. They were well marked at the pond, but farther on they forked and branched until they finally disappeared.

The pond once extended about 25 feet farther west than at present, as the old dam is plainly to be seen, though mostly filled in on the upper side. There was a little water toward the farther end. A stream enters the westerly end of the pond, and here was a small pond, about 20 by 25 feet, irregular in shape. The water was 24 inches deep and very clear. The dam looked fairly old, but I do not recall seeing it in 1921, though I am quite sure I was at that part of the colony. In the water at the outlet was a freshly cut stalk of wild geranium, a plant growing very rankly all about. About 25 feet above this pond was another smaller shallow one, and above that the water came trickling down in streamlets, perhaps from springs, or possibly the seepage from the creek disappearing under ground and then reappearing shortly below.

The lodge was 7½ feet wide, 12 feet long, and 38 inches high, above the water level, and the water at the entrance was 18 inches deep. At the northeast corner was a stump 24 inches across, sawed off long ago, and very rotten. It was 4 inches higher than the top of the lodge. While I was photographing the lodge, my assistant, who was standing beside it, broke through close to the edge. I found that the lodge was very thin here, and was able to introduce a rule into the opening 43 inches, bringing the end under the point on top where I had thought the ventilator to be.

At Pond No. 3 cutting had begun among the small spruce. Back of the lodge one 2 inches in diameter had been cut almost through 27 inches above the ground, and cut off 37 inches high, where it was three-fourths of an inch in diameter. There was no trace of the top. A few feet away from the lodge were six small spruce stumps in a group, three-fourths to 2 inches in diameter, and the tops were all gone.

At the westerly end of Pond No. 3 a trail led off to the west. A spruce tree about 7 inches through at the butt had fallen over the water near where this trail leaves the pond, and several of the small branches on this had been cut off by the beaver, some of these being horizontal, others upright. The highest was 45 inches above the water and 20 inches above the log. Off to one side in a tangle of brush was a spruce sapling severed 58 inches above the ground, where it was 1½ inches in diameter. A few inches below the top the bark had been gnawed off for 6 inches up and down, and about halfway round the tree. A little distance away from this a 1½ inch spruce had been cut off 38 inches high. This was more recent work than the other and the stump still had fresh foliage on it.

All about here were old alder stumps, and at one place five alders from 2½ to 4½ inches in diameter, had recently been cut down. This had either been done in the spring of 1923, or possibly late in the preceding autumn, but certainly when the ground was bare, for the stumps are low. A tree 4½ inches through was 36 feet long.

A surprising number of small spruce had been cut near the above mentioned small ponds, a few quite recently. They ranged in size from 1 to 3 inches in diameter, and while mostly cut off rather low, a foot or so, some were higher, and one 3 feet.

On the same stream below the Yancey barns we found trails running back from the water to small willows, and green willow twigs in the water at the beginning of one of them.

PETRIFIED TREE ROAD COLONY

Season of 1923. This colony is a series of ponds on the upper part of the South Fork of Elk Creek, lying in a ravine below the road to the Petrified Tree. It can easily be seen by anyone driving along that road. It was visited on July 21, 24 and 27, and August 3. Altogether there is a group of nearly twenty ponds and dams, extending from a point opposite the Petrified Tree down to the crossing of the main loop highway. The lower ponds are now empty and the dams overgrown with grass, and evidently they have not been occupied for some years.

The most interesting place was a drained pond containing a very large lodge (Fig. 43), about 30 feet in diameter, and 8½ feet in height above the bottom of the pond. The tape was stretched around the base, and gave a circumference of 99 feet, following the various inequalities. Ten entrances were found, most of them at the bottom level. One opening could be entered and chambers or rooms were examined which will be described below.

The dam which had formed this pond was 313 feet long and 6 feet high on the upper side. It had an east and west course. The house was 50 feet from the dam, at a point 137 feet from the easterly end. The outlet where the stream flowed through the dam was 42 feet from the east end. The pond was a waste of fallen logs and stumps. Most of the large standing dead timber killed by flooding several years ago, had been cut this past winter when the ponds were frozen, for firewood at Camp Roosevelt. The dead conifers were nearly all Engelmann spruce, with an occasional Douglas fir.

Below the dam were a couple of ponds, full of water, the dams about 50 feet long, then one partly full, next a full pond with a 60-foot dam, then a larger pond where there was a bank lodge built upon a little peninsula projecting into the pond. This lodge was 5 feet high, above water level. The water was 41 inches deep near the entrance. The dam at this pond was 200 feet long, 4 feet high on the face, and the water was 28 inches deep where the face was measured. This dam was an old one, with much grass growing on the crest, but was in excellent repair. In places along the crest were green algae brought from the pond, whether purposely or not, I cannot say. There were three or four more ponds below this, seemingly used more for travel than for homes.

Above the pond with the big lodge, which once had been a hundred yards or more long, were two old dams. Below the lower one of these was a small pond,

Fig. 43 (6025). Petrified Tree Road colony. The big lodge from the dam. The forest is Engelmann spruce, the portion killed by flooding mostly having been removed for firewood. July 21, 1923.

Fig. 44 (6038). Petrified Tree Road colony. The opening made in the big lodge. The rule stands 4½ feet high at the point where the two chambers separated. July 27, 1923.

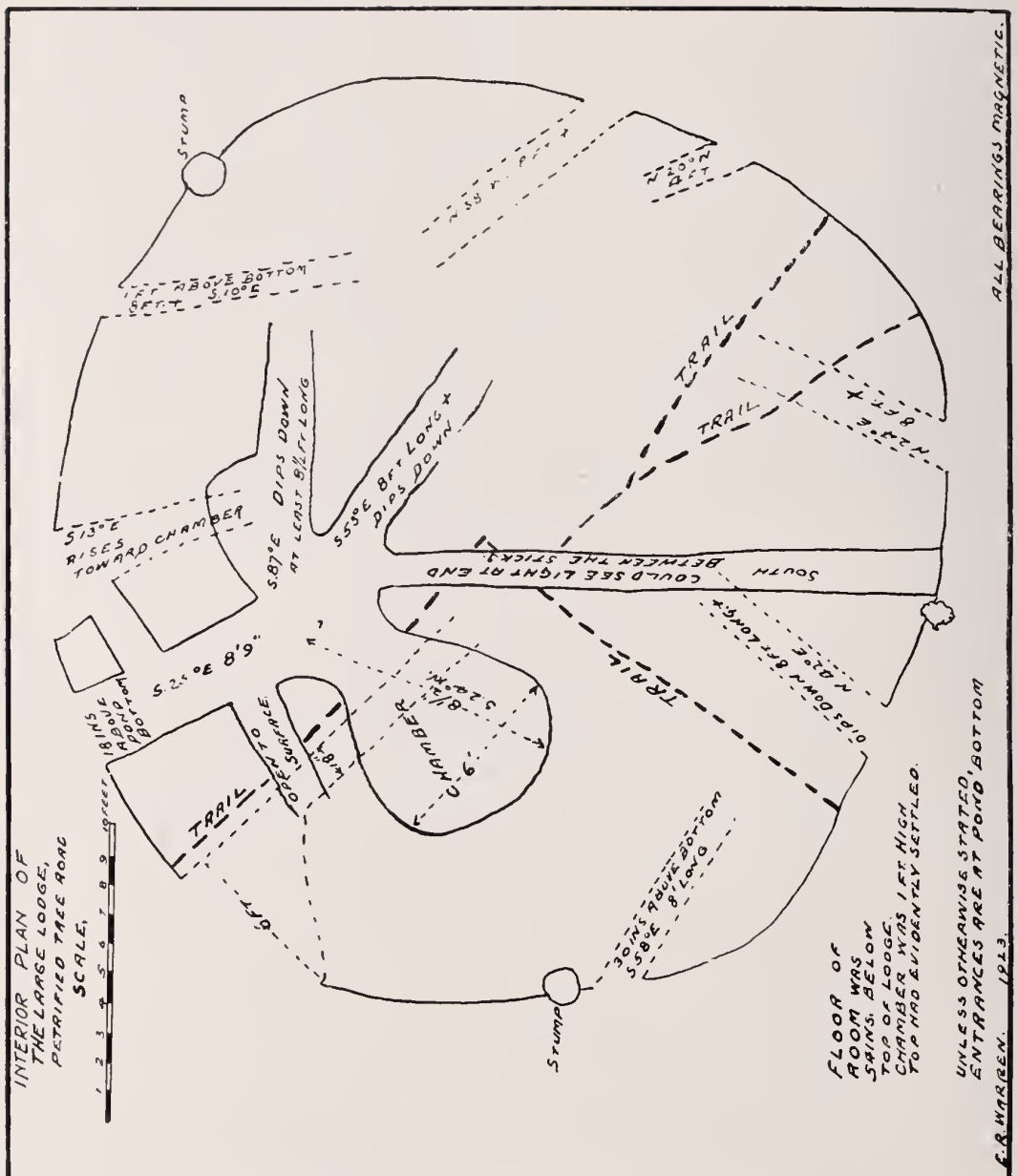

Fig. 45. Plan of interior of large beaver lodge at works near the Petrified Tree Road. July 27, 1923.

with muddy water, as if it had been lately used. Above these was another long dam, 300 feet in length, old, and much covered with grass. The pond was full of water, and in it were many piles of brush left by the woodchoppers. These were fresh, and raised the question as to whether they had been left on the ice and settled into the water, or whether the pond had been empty when they were made. Although I made inquiries I was unable to get any information as to this point.

A hundred yards above was another pond with a 200-foot dam, very crooked, and some of it quite low. Then came a small pond, followed by one with a 100-foot dam which backed the water up 100 feet to the next dam, which in turn was 125 feet long. At the pond behind this dam was a bank lodge 15 feet from the shore, 8 by 10 by 3½ feet high above the water. Above this pond were two or three smaller ones, the uppermost of the series, which were about opposite the Petrified Tree.

Near these upper ponds, very recently made and now in use, the beavers had been felling the remaining aspen trees, mostly on the easterly side, as the forest on the other is principally dense conifers, as shown in Fig. 43. These aspens are all large, and the supply will soon be exhausted, even though the animals seem to be utilizing them to the fullest extent, cutting off all the branches and eating the bark from the trunks.

At the lowermost ponds used I could find little evidence as to what the beavers were living on. A few small peeled sticks were in the water near the lodge. Small willows were growing some distance away, but I saw no beaver cuttings among them or among the fly honeysuckle bushes which grew abundantly there. No herbaceous plants appeared to have been touched.

The Lodge. The lodge was so old that much of the material seemed to have settled considerably, and the various entrances were rather difficult to trace; for though I tried pushing a wire into them, this often seemed to meet with some obstruction. Nearly all of these entrances were at the bottom level of the pond, and some of them appeared to dip somewhat below that level as they went under the house, and water was standing in them. Very possibly this downward pitch may have had something to do with my failure to get good results with the wire. However that may be, the greatest length I obtained was a trifle over 8 feet. Most of these entrances pointed more or less toward the center of the lodge. One or two, as shown on the accompanying plan (Fig. 45) had very different courses.

We attempted to excavate and make an entrance into the rooms, but found it difficult work. An open cut was made along the entrance which led to these (Fig. 44). When this was a little more than 8 feet long it reached a spruce or fir log lying at right angles to its course. This was 8 inches through and in such a position as to bar further progress. This work was done July 27, and on this date I could squeeze myself into the openings of the rooms, which were about a foot high. At the right, just outside the above mentioned log, was a room the entrance to which was about 2 feet wide, but which expanded to a width of 6 feet, and a depth of 8½ feet.

On the left, beyond the log, was a cavity which had three branches. The right hand one extended clear through to the other side of the lodge, and I could see light through the sticks at the end. It dipped downward but little, and therefore probably was not connected with the entrance which was at that part of the

lodge. The middle branch dipped downward very suddenly about 4 feet from the entrance, and was more than 8 feet long. Because of this dip and the cramped quarters I was unable to ascertain more about it. The left hand branch also had a downward pitch and likewise was more than 8 feet long. For a distance of 4 feet from the entrance it was expanded 2 feet or more on the right side, and the whole floor space between the entrance and where these passages began made a fair-sized room.

On August 3 I visited the lodge again, and found that the top had settled so much that I could no longer get inside, and therefore learned but little more. Most of the sticks composing the structure were more or less decayed, and our digging may have started this settling movement.

The entrance which we turned into an open cut was 30 inches wide, and 18 inches above the pond bottom. The floor of the opening into the chambers was 54 inches below the top of the lodge, and some 4 feet above the pond bottom. The entrance was 12 inches high when the excavation was begun.

As the diagram shows, there were trails over the top of the lodge.

In the large right hand chamber were porcupine quills and dung. Woodchucks were also seen about this lodge and running across the dam.

ELK CREEK BENCH COLONY

Season of 1921. On the flat ridge above Yanceys, between the North and South Forks of Elk Creek, is a group of beaver ponds which present some interesting features (Map 7). The water supply is a small brook originating from springs in a boggy tract of several acres densely covered with old growth Engelmann spruce. The brook flows through a flat depression in the ridge, and it is in this swampy, springy ground just below the woods that most of the ponds are located. Below the flat the stream has cut a deep gully, now littered with the ruins of old decayed dams, and finally joins the North Fork of Elk Creek. The ridge itself is quite flat. On the northeastern side of the ponds for some distance there are no trees, while on the western side there are aspen groves, succeeded farther back by Douglas fir, and in the boggy grounds, Engelmann spruce. The land on either side of the ponds from about Pond No. 3, south, is a gently sloping hillside.

This series was first examined on July 23. It included one large pond and four smaller ones. Later, on September 4, two more ponds were found to have been added. The largest, Pond No. 1, is formed by a dam 85 feet long, with an upstream curve (Fig. 46). This is built at the extreme end of the flat, where the stream outlet begins to fall rather sharply to the ravine below. Consequently, though this dam is comparatively short, it makes a large pond, 350 feet in length and 225 feet in its greatest width. When the first examination was made the pond was quite full of water, though none was escaping over the dam, that is to say, the evaporation and seepage just balanced the flow of the springs. On subsequent visits it was noticed that the water was falling, and by September 4 was very low, and mud flats were exposed (Fig. 47). The dam was somewhat peculiar in that considerable green algae from the pond had been placed on the top, and it certainly seemed rather effective as a protection to the mud. This dam was built mostly of mud and small sticks, and the number of large sticks was scant.

Fig. 46 (5072). Elk Creek Bench colony. Pond No. 1 from the southeast, July 23, 1921. Water at maximum height.

Fig. 47 (5268). Elk Creek Bench colony. Pond No. 1 from the southeast, Sept. 4, 1921. All except lowest parts of the pond are drained.

Fig. 48 (6129). Elk Creek Bench colony. Pond No. 1 from the southeast, Aug. 17, 1923. All except lowest parts of the pond are now covered with marsh grass.

Fig. 49 (5073). Elk Creek Bench colony. The long lodge as seen from the southeast. July 23, 1921.

Fig. 50 (5271). Elk Creek Bench colony. The long lodge after the draining of the pond, showing entrance and channel leading to it. Sept 4, 1921.

Along the southwestern shore of the pond are a number of drowned aspens, standing, besides fallen trees, most of these latter having been cut by the beaver. There are thirty or more stumps and cut trees in and along the edge of the water. There are also dead, and a few living, willows standing in the water along the edge of the shore. Several trails and canals lead from the pond back to the aspen grove. At one point is a canal and a succession of underground ways. Beginning at the water's edge it is first open for 12 feet, thence 3 feet covered to an open hole, thence 7 feet covered to an open hole, thence 3 feet covered to an open hole, thence 2 feet covered to an open hole, thence 3 feet covered to an open hole, thence 3 feet covered to an open hole, and 3 feet more underground. This may be a burrow which has been broken through to the surface by the beaver at these open places, or it may have caved in naturally. Nowhere was the thickness of the earth over the passage much more than a foot.

About 275 feet along this shore from the dam the open water ended and there was an area of flooded grassland. Along the northeastern shore of the pond, in the water, are dead willows and aspens, though the latter are not so large as those on the other side. In the pond are two lodges. One is an irregularly elongated affair and looks as if advantage had been taken of a natural elevation upon which the lodge had been built (Figs. 49, 50). At the end which projects into the pond it was composed of earth, and had grass, thistles, fireweed and willow shoots growing upon it. At the end next to the shore were aspens five inches in diameter, three of which had been cut down; one is partly embedded in the lodge. This lodge is 25 feet long by 12 wide; the highest point is 10 feet from the shore end. There is much mud and earth in the lodge, with plenty of sticks covering it. The second house is of the typical round shape, with mud and grass, and many sticks and poles, the longest of which appeared to be 10 feet or more in length, and 3 inches in diameter. A bunch of willows was growing at the northern side. On September 4 the water was so low that entrance holes were exposed on two sides of the long lodge; they showed no signs of being used, while the round lodge was certainly in use. (See Figs. 50, 53.)

Seventy-five feet above the southerly part of the large pond was located Dam and Pond No. 2. The dam was a low one, of mud and grass, and there could hardly be said to be a pond here, but a ditch three feet wide made by digging out the material to construct the dam (Fig. 51). From the dam a channel or canal leads to the pond below (Fig. 52). Back of the open water in the pond are marsh grass and willows; the ground is swampy, but the water is not above the grass tussocks.

Offset fifty feet northeast from this is Dam No. 3, 180 feet long, very crooked, and lying in such a position that it appears to protect the large pond below. Like No. 2 this dam is built of grass and mud excavated from the pond side, but there is much more open water than in Pond No. 2. Above it is water in pools amid the grass and low willows. From the dam down to Pond No. 1 is a canal three feet or more wide, with mud thrown up on either bank for most of the distance; the deepest portion is probably about two feet wide, and it appears to be the same in depth, with shallower water on either side. It is apparently a natural channel, deepened. There is a little dam across it about three-quarters of the way up from Pond No. 1. Above this miniature dam the channel is narrower.

The northeastern end of Dam No. 3 is at the edge of the solid dry ground, and from here, southeasterly, there is a gently sloping hillside above the ponds.

Seventy-five feet further southeast is Dam No. 4, 70 feet long, making a fairly large, but rather shallow pond. From the end of the dam a trail leads off into the woods, which are rather open, composed of large aspens, mixed with conifers. Some of the aspens had recently been cut and the bark eaten. In this pond, as also in the next one, No. 5, are a number of standing and still living Engelmann spruce trees. It is approximately 75 feet southeast from Dam No. 4 to No. 5, which is 65 feet long, flooding a considerable area, but shallow, and with grass at the upper end. Along the north shore of the last two ponds are a few fair-sized lodgepole pines, with a good many small ones coming up.

As this new series of ponds above the main large one apparently was not actually colonized at the time of my examinations during July and early August, it was a question as to what use they were to the beaver. They could not serve to break the force of the water and protect the main pond, as floods would not occur on this flat at the source of the brook. Nor was it a matter of surplus water storage, as the main pond was being permitted to gradually drain. The additional ponds were not necessary for transporting aspen sticks and construction materials, as abundance of aspen was still available along the west shore of the original colony pond, and handy to the lodges. The observations made on September 4, however, showed that some of the beaver had now taken up their abode in Pond No. 5; possibly as an overflow from the colony in the large pond, forced to leave because of the crowded condition in the lodges. On the other hand, as the water in the large pond was draining out, and a new lodge was now being started above, the whole colony may have moved, not from necessity, but from choice.

On the southwest side of the large pond is a large grove of aspens from which the beaver were obtaining their main food supply in 1921, and where they were doing considerable cutting. This grove was measured. It was 95 feet along the northwestern side from the shore to the corner of the grove, thence 187 feet along the western side, thence 170 feet back to the pond. About half of this area has green aspens on it, and mingled with these are a good many dead trees that have succumbed to the natural crowding, possibly a quarter as many as those living, and the part nearest the water has only dead trees, these latter killed by submergence. Southwest of this grove is another, which really joins onto it. The nearest trees in this grove are one hundred or more feet from the water. In the main grove one tree has been cut 105 feet from the nearest water. Green trees in the grove where cutting is going on run up to eight inches in diameter; there are old stumps somewhat larger. The ground here is level and the deepest cut appears to be made indiscriminately on either side of the tree; many which stood apart, especially the larger ones, have been cut evenly all round (Fig. 120).

On my last visit this season, September 4, the following additional notes were made:

Pond No. 2 was full of water, while No. 3 was somewhat low. Dams Nos. 4 and 5 were built up higher; the latter was at least 100 feet long and 3 feet high, and its pond was at least 60 feet long on the east side, and covered a greater area of ground than before. In the southern part of this pond, apparently in the newer portion, was a small lodge, built sometime since August 10. This looked

Fig. 51 (5138). Elk Creek Bench colony. Pond No. 2 just after construction, its low dam built chiefly of mud and grass. Aug. 10, 1921.

Fig. 52 (5137). Elk Creek Bench colony. A trail and canal leading into Pond No. 1. Aug. 10, 1921.

Fig. 53 (6002). Elk Creek Bench colony. The round lodge in Pond No. 1 as it appeared July 10, 1923. Part of aspen grove in background killed by flooding.

Fig. 54 (6004). Elk Creek Bench colony. The lodge in Pond No. 5, showing the break in the side. Pond formed in 1921; submerged Engelmann spruce now dying. July 10, 1923.

to be about 10 feet in diameter and 3½ feet high above the water level. It was well plastered with mud and covered with sticks. There were aspen boughs stored in the water beside it; this being the only instance of storing food in anticipation of winter which I observed during my stay in the Yancey region in the summer of 1921.

Southwest of this pond was another, a new one with a dam 50 feet long, and back of that a dam 100 feet or more in length, the westerly end of the pond being narrow and leading to the aspen timber. All this new work was executed in a month's time and shows how active this colony is.

Three aspens had recently been cut below Dam No. 1, and another partly cut; also one dead tree had been cut on the dam, and another partly cut.

Season of 1923. This colony was examined July 10 and August 17. On the former date I found Pond No. 1 drained except for a trifling amount of water in the old channel. This was not surprising, for when I last saw the pond in 1921 the draining was far advanced. The pond presented a desolate appearance with its expanse of mud interspersed with dead willows. Grass, however, was growing well out from the shores on the first date, and on the last had pretty well covered the pond (Fig. 48); and soon it will be a beaver meadow, unless the beavers return for the remaining aspens. On the shore at the northwest corner of the pond was quite a little area blue with that species of pentstemon which rather favors damp places (*Pentstemon procerus*). While most of the pond bottom was firm enough to walk upon, in some spots the mud was soft, deep and treacherous.

The draining of the pond had of course exposed the two lodges so that their full size was shown to good advantage. The long bank lodge had six entrances, one on the end toward the pond, one at the shore end opening into a canal, and the others on either side. This lodge measured 23 by 21 feet, 66 inches high above the bottom of the channel at entrance, and 54 inches above the general level of the bottom. The two entrances which I measured were about 12 by 12 inches.

The round lodge had an entrance toward the pond and one toward the shore, and one or more on each side. It was an enormous pile of sticks, 26 by 28 feet, and 6 feet above the general bottom level, plus one foot to the bottom of the channel. Outside the lodge, not far from one entrance, were two small piles of trash which may have been thrown out in house cleaning. A channel runs from near the outer entrance of this house along to the southeast corner of the long lodge, and thence around the east end of the latter and connects with the ditch there.

Logs cut on the shore of this pond in 1921 had not been used, though the branches and tops were removed that year, and there were still plenty of standing trees available.

Pond No. 2 was empty. Pond No. 3 had water in it, and the trail over the dam looked as if it were being used occasionally. Pond No. 4 also contained water.

Pond No. 5 was full and much larger than when I surveyed it in 1921, and the lodge was likewise much larger than when I saw it in September of that year. The dam measured 82 feet long, an increase of 20 feet, and the pond measured 130 feet along the east side from the dam to the upper end, nearly double its former length. At this end a trail led out to where the beaver were cutting large

aspens. One 12-inch tree had been felled, and the bark all eaten from the trunk some time previously, the branches also having been removed. One 12-inch and one 6 by 12-inch aspen growing from the same root, and a 7 by 12-inch aspen growing close by were all cut into a little. On August 17 these were still standing.

On the northerly side of the pond, 6 feet above the end of the dam, was a burrow. The water at the mouth of this was 3 feet deep. Some three or four feet in on the bank the top had apparently broken through and peeled sticks had been piled over the place. The water in the pond out from the dam was from 24 to 30 inches deep in some places. I found an old aspen stump on the shore freshly gnawed much like one or two noted in the Longs Peak region in 1922.

One side of the lodge was broken down quite vertically from some undiscovered cause (Fig. 54). From a point directly opposite this it looks very much as if an entrance was exposed, or possibly a partial opening made into the chamber. This house was probably about 15 feet in diameter on the waterline, and 5 feet high. It was 25 feet or more from the nearest shore. Some of the submerged Engelmann spruce was dead.

Near the northwest corner of Pond No. 5 was a burrow which extended back at least 12 feet from the shore. Also from this place a trail led up the gentle slope to a grove of large aspens, where a number had been felled, the branches cut off and carried away, and much of the bark eaten from the trunks. These cuttings were 150 to 175 feet from the pond.

Above Pond No. 5 was a small irregular pond, No. 6, which did not have much water in it. There was a connection through the dam between the two ponds. No. 6 was evidently once considerably larger than when seen at this time, but the water had drained out. A small dam had been made to one side and this had fresh mud plastered on it. Though the ground is springy and swampy above here there was no more beaver work.

I found an aspen log which had had eight cuts in it in a space of 10½ feet, varying from slight notches to those extending halfway through the log, which was 9 inches in diameter at the butt and 6 inches at the small end.

On August 17 I made some further examination of Pond No. 1. An entrance at the east end of the long lodge, near the southeast corner, extended more than six feet under the side of the house, parallel with its axis. Three or four feet inside a passage turned to the right, possibly connecting with another entrance. A hole in the side of the lodge opposite the highest part permitted the introduction of a stick five feet long, which by probing indicated the presence of a room there. It was 22 feet from the east end of the lodge to this highest part.

NORTH FORK OF ELK CREEK

Season of 1921. On the northernmost of the tributaries of Elk Creek coming from the west, and itself comprising two branches, — one from Crescent Hill and the other from the ravine farther south, known where the loop highway crosses it as "The Gut," — is a long series of beaver dams. As in the case of the Bench series, previously described, those works in the ravine on the lower course of the stream were for the most part long since abandoned, but the flat above the head of the ravine is now the home of a very prosperous colony (Maps 8, 9, 10). The lower 13 dams are in the abandoned section, though in the summer of 1921 beaver

Fig. 55 (5218). General view of Elk Creek beaver ponds. North Fork works at right, Bench colony at left; valley of Yellowstone River in distance. Aug. 22, 1921.

Fig. 56 (5216). North Fork of Elk Creek colony. View from high hill-slope on northwest. Dam No. 1 in lower left corner; Dam and Pond No. 2,—the long dam with lodge; Dam No. 3, above main pond, at left. Aug. 22, 1921.

Fig. 57 (5060). North Fork of Elk Creek. Near view of Pond No. 2, lodge, and Dam No. 3 above, from foot of slope on northwest. July 21, 1921.

Fig. 58 (6130). North Fork of Elk Creek. Pond No. 3 (in foreground) and No. 2 (beyond) from bench on the southeast, showing drowned spruce and works somewhat dismantled. View downstream, Aug. 17, 1923. (See also Fig. 59.)

were at work at the lower end of this portion, and in some cases appeared to be making use of parts of the old dams. I paid but little attention to these, however, practically confining myself to the upper series where the animals are now especially active. The first examination was made July 21, and the place was visited on various subsequent days, the last visit being made September 4.

Where this series is located there is a low, flat-topped ridge on the east, on a depression of which the "Bench" colony is situated. The slope of this ridge next the North Fork works is steep but not high (Figs. 55, 56). On the west of the North Fork the lower hill slope is gentle at the bottom, but steep and high above, and covered with grass and sagebrush. While on the eastern hillside all the aspens were cut years ago, on the west side there is still a considerable number of living trees which the beaver are now engaged in cutting. On the swampy, wooded flat some 500 feet wide, above the large pond, the trees are mostly lodgepole pines, Engelmann spruce and Douglas firs, with some aspen. Along the stream are also alders. The lodgepole pines and scattered large aspens are found on the western half of the flat, while the firs are on the eastern half. Elk Creek runs on the west, supplying the water for the series of ponds on that side. On the east side there appears to be no distinct stream, but the ground is very wet and swampy, covered with long grass, and supports a growth of alders, low willows, and firs, the last being mostly rather small although there are some good-sized trees, especially along the border of the flat. On the hillside opposite Ponds No. 13 to No. 17 are aspens, some of which the beavers had begun to use.

Of this new series of dams, the lowest, No. 1 (Fig. 56), is more than 160 feet long, bending both upstream and downstream, and extends from the foot of the hill on the east across to the more gently sloping ground on the west. It is an old structure, 3 feet high on the lower side, and somewhat more than the west half is overgrown with grass and other plants. The sticks on the lower face look very old, and there is much mud showing; this face is now very flat. At present it is scarcely used, and the pond has been largely filled up with sediment. A trifle less than the lower half of the pond is a mud flat with some water standing on it. The remainder is overgrown with grass and small scattered willows. It affords an excellent illustration of the manner in which a beaver pond is gradually converted into a meadow. The only indication of this section being occupied at all is a small dam across the creek a short distance below Dam No. 2. At the time of the examination it formed but a tiny pond and it remains to be seen whether this will be enlarged.

Dam No. 2 is a splendid new structure, the longest I found anywhere, more than 350 feet if measured along all the curves, and 5 feet high on the lower face. Like the preceding dam it extends from the hill on the east across to the more level ground on the west (Figs. 56, 57, 60). At the western end the dam was built mostly of mud and grass, as if the beaver were hastily lengthening it to stop the flow of water around the end, and fresh mud was also being laid all along the top. The water overflows much of this dam, and there were several small streams flowing over the top near the east end. Though the dam is so very long the pond is not wide upstream, and will hardly average a hundred feet to the nearest dams above. The sticks lying on its lower face were mostly old ones, though there were some newly peeled.

On the west shore of the pond (No. 2) were several trails leading to the little grove of aspens there, where the beaver have been cutting during the past summer. At the southwest corner of the pond a ditch ran southwesterly for 40 feet toward Dam No. 5, with a trail beside it most of the distance (Fig. 65). This ditch was 18 inches wide and 12 deep. In the southeastern part of the pond, not far from Dam No. 3, is a fair sized beaver house. On the side of this, nearest Dam No. 3, was a much used trail from the water to the top. This lodge, as Fig. 62 shows very clearly, was well covered with sticks of various sizes. A canal extends from Pond No. 2 to a point opposite the west end of Dam No. 3, with a trail from its end through the grass into the timber.

Dam No. 3, approximately 240 feet long, and 6 feet wide at the base, is somewhat crooked, especially at the southwest end, where it turns in a somewhat peculiar manner, apparently having been built along as needed to head off the flow of water around the end. The pond now had but little water in it, and thus the mud construction of the upper side of the dam showed very clearly (Fig. 64). About 70 feet from the easterly end there seemed to be a hole or tunnel through the bottom of the dam to Pond No. 2, and the water level in both ponds appeared to be the same. A stream flowed along the southwestern side of the dam toward the tunnel in a channel which looked somewhat as if it might have been excavated, and other small streams came in from the southeast, while there appeared to be no other outlet to the pond. Along the west end of the dam, on the upper side for more than 50 feet, is a trench which is probably the place from which the material for that part of the dam was obtained. There was a trail over the dam about 80 feet from the easterly end. On the east bank of the pond lay a spruce tree, cut long ago; this was about 10 inches in diameter. In the pond are many fallen spruces and several standing dead ones. Under the east bank are several holes evidently once used by the beaver, and half buried in the mud near this bank I found a beaver skull (Field No. 5501).

Beyond the water area in Pond No. 3 many small willows are growing on the flat which is presumably part of the old pond bottom, while long swamp grass, alders, and small spruces conceal what is above. It was somewhat of a surprise when one worked his way along for 240 feet above Dam No. 3 and came out of the thicket upon a dam 137 feet long which he could not see until within a few feet of it. This dam, No. 13, appeared to be a quite new structure, built of mud excavated from the bottom of the pond. The water where measured close to the dam was three feet deep. On the lower face of the dam are dead sticks and roots, some of the latter apparently dug from the pond. A recently cut dead aspen stick, two inches in diameter, was on this dam; and what appears to be the tree from which it was cut still stands in the water, with the severed end four feet above the surface. This tree seems to be rooted in the ground and I am rather at a loss to understand how a beaver could have cut it off at such a height, unless during the winter when the snow was deep. The open water in the pond is irregular in outline, quite narrow at the ends, and about 50 feet wide where it extends up to Dam No. 14. The grassland here is also flooded. The eastern end of Dam No. 13 is 25 feet from the base of the hill.

Dam No. 14 is only about 25 feet long, curved downstream, and backs the water up to the base of No. 15, which is another long one, 140 feet, with its east

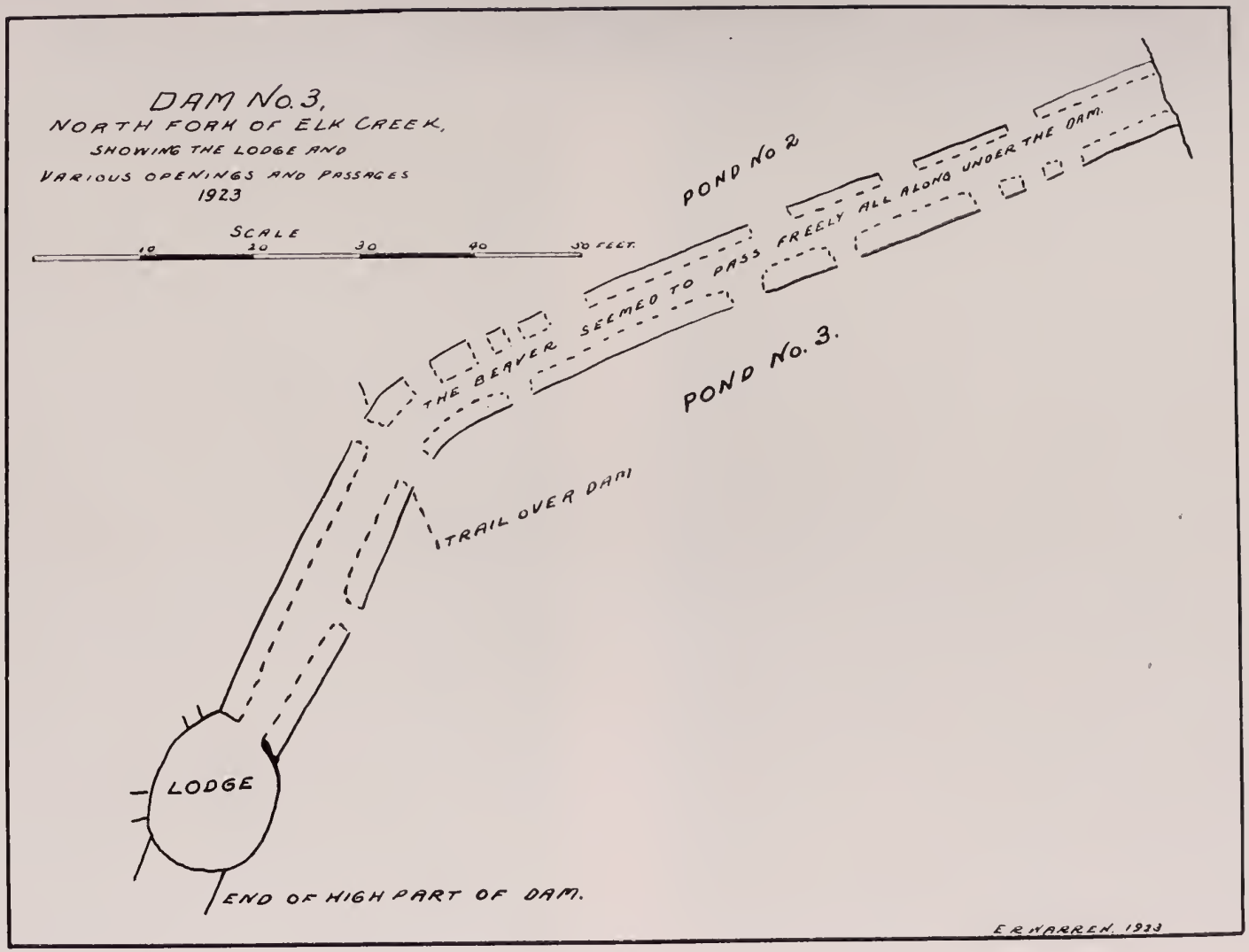

Fig. 59. Diagram of dismantled Dam No. 3 at beaver works on North Fork of Elk Creek. Aug. 1, 1923.

Fig. 60 (5145). North Fork of Elk Creek. Dam No. 2 from slope on the east. This is 350 feet long, the longest dam in the Yancey region. Note the thick willow growth. Aug. 10, 1921.

Fig. 61 (6005). North Fork of Elk Creek. Dam No. 2 from slope on east, showing break and dilapidated appearance, July 12, 1923.

Fig. 62 (5100). North Fork of Elk Creek. Beaver lodge in Pond No. 2, from Dam No. 3. Note its fresh condition, well covered with sticks. July 30, 1921.

Fig. 63 (6042). North Fork of Elk Creek. Beaver Lodge in Pond No. 2, from Dam No. 3. Appearance July 28, 1923, the overlying sticks much broken and rotted away.

end braced against the foot of the hill, and extending southwest across the swampy flat. Like No. 13 it is built of mud dug from the pond, while sticks, mostly dead, and many half rotten, lie on the face. Several freshly cut green alder sticks were also on this dam, with the bark uneaten, as if the beaver did not care to eat this when they could get aspen; together with the green tip of a small fir, 18 inches long. The open water of Pond No. 15 was irregular in outline, with flooded grassland about it. A trail led from the southerly side of the pond out through the grass, and there were others from the east end up the hill, where half a dozen aspens had been cut. The water in the pond was 3 feet deep near the dam.

About 60 feet above Dam No. 15 is a short one (No. 16) 44 feet long and 3 feet in greatest height, with a shallow irregular pond, not more than 20 feet in its greatest width upstream. While some parts of this dam appeared rather old, much of it was certainly newly built, and there were rotten sticks laid on the face, which had not been there long. Ninety-five feet farther on was another small dam (No. 17) 30 feet long. Between the two was a dam so small that I made no account of it. From No. 17 it was 50 feet farther to another small dam, 20 feet long, from which a trail led on a little pool offset to the left. This was the end of the work on this side of the flat. Above, the ground was swampy, with much water under foot, and rather thickly covered with willows, alders, and scattered small firs and spruces. Through the whole area of these ponds occasional old aspen stumps are to be found. As there is no stream above these last little ponds, and the ground is so wet, the water evidently was supplied by springs.

I could discover no holes in the bank at Pond No. 13, but at No. 15 a hole was found under a large fallen log lying in the water next the shore, and it appeared to extend under the bank.

On the west side of the flat above the big pond, No. 2, is a separate series to which I have given the numbers 4 to 12. A double line of ponds along separate rivulets, extends from Pond No. 2 up to No. 10. Dam No. 4, 90 feet long, is built just above the upper margin of Pond No. 2 and about 100 feet northwest from the nearest end of Dam No. 3, opposite. It makes a small pond, not much more than 30 feet wide in its greatest extent upstream. The margin of Pond No. 2 is for some distance only from three to ten feet away. A short distance above, southwest from this pond, is another smaller one which has been filled up.

Less than 40 feet west from Dam No. 4, on the rill nearest the hillside, is No. 5, about 45 feet long, with a very pronounced angle downstream, making a pond at least as wide up-and-down the stream as the dam is long, but shallow (Fig. 66). There were 6 dying lodgepole pines in this pond, from 25 to 40 feet in height. A short canal came into the upper end of the pond from the west, while another nearly 30 feet long connected the pond with No. 6. This canal was 16 inches wide and 14 deep. Pond No. 6 was a small one with a dam only 20 feet long. About this pond several large aspens had been cut — some had fallen across the pond, — and from these the bark had been partly eaten as they lay there. It is only a short distance from Pond No. 6 up to No. 7, with a 60-foot dam. This pond is very narrow, 20 feet wide at most, measured upstream. It receives its water supply from a flow coming around the west end of Dam No. 10. A large aspen with most of the bark eaten off was lying across the pond. South of this pond, on July 21, the date of the first examination, was standing

an aspen 4.6 feet in circumference, cut partly through all around by beaver. This was still standing and untouched August 28, but had been felled before the last visit was made, September 4 (Figs. 118, 119). There was a short canal near the end of Dam No. 7, measuring 24 inches wide and 12 inches deep.

Southeast from here, on the adjacent flow, was Pond No. 8, a small one, the overflow from which supplies Pond No. 4 direct. Dam No. 9 a short distance above No. 8, is 40 feet long, and the pond had been filled up with gravel, flush with the top of the dam, and there were several rivulets flowing through it.

Pond No. 10 is some 40 feet southwest from the preceding, and is formed by a dam 115 feet long, though the pond, like most of these in the west series, was narrow and shallow. The dam was two feet high on the lower side. At the west end a canal ran westerly 18 feet. This pond had four or five dying pines in it, and also several clumps of willows. Though there is but one inflowing stream, there are several outlets.

Dam No. 11 had a very sharp downstream angle, and was about 40 feet long. In the pond was an alder 2 inches in diameter cut off 7 feet above the ground, and a smaller one cut at about 5 feet up. Possibly the animal was out on deep snow when this was cut, or the tree may have been bent down by the weight of the snow so that the beaver could cut it at this point, and when the snow melted the tree resumed its former position. Dam No. 12 was nearly 100 feet long. The eastern portion of the pond was filled with silt to practically the level of the dam. The greatest width of the pond was about 40 feet. Two large aspens had been cut above the pond.

The stream above the last ponds flows through a channel 4 feet wide, the banks being a foot or more high, with alders growing upon them. At the time this observation was made, July 30, the water meandered along the channel, never completely covering it, usually not more than half, and was from two to three inches deep. No doubt when the snow is melting in the spring the stream is full to the top of the banks, if it does not overflow them.

Of this western string of ponds, Nos. 4, 5, 6 and 7 are recent work, the others are quite old. The principal use of these ponds would appear to be the retarding of the stream flow and protecting the large lower pond during the season of high water. Also, to some extent they afford a waterway for the beaver in their movements and perhaps are useful for transporting logs, although there were fallen trees over some of the ponds which one might think would interfere with this work, especially as the water was rather shallow in all of the ponds.

The forest growth along the slope near the flat and stream, excepting the alders growing immediately upon the banks, is mainly pines and firs, with a few large aspens scattered among them. The aspens now being utilized by the beaver were all on the western side, and mostly opposite Pond No. 2. A count of the trees was made here, with the result that 16 living trees were found still standing, and 37 recently cut stamps. In the somewhat separate grove above Pond No. 5 59 standing trees and 52 stumps were counted. As usual, there were trees here which had been felled and never used.

On September 4 the stream was examined for more than a mile above the last pond. The character of the banks varied considerably. Often the stream was in a narrow gulch, with steep rocky sides; in other places the valley was

wider, with easier slopes, and occasional almost flat areas overgrown with grass and willows. There are not now very many aspens anywhere along this portion, and the timber is pine and fir; also some Engelmann spruce. Two or three aspens had recently been cut a quarter of a mile above the last pond, and some distance above this I saw where beaver had cut bark from a late windfall.

Three-quarters of a mile above Pond No. 12 I found the highest stumps seen anywhere this season. Six of these measured 3.95, 3.9, 3.65, 4.15, 3.55, and 3 feet in height respectively. Other stumps near by were of the usual height. This was all old work. The logs from these tall stumps had never been used, but still lay where they had fallen. There was a hole under the bank near here. There were two trees cut in 1921 nearly a mile above the uppermost pond.

More than a mile up are also the ruins of solid old dams, the first about 5 feet high. Sixty feet above it was a very massive old dam, about 6 feet high and thick in proportion, and about 50 feet long. The right bank along these dams is about 6 to 8 feet high, and steep, with a more gentle slope above this, while the left bank is steep for 100 feet or more above the stream. One hundred yards or so above the last mentioned dam were two more, about 50 feet apart and each 50 feet long. Here the western hillside was grassy, with some willows. I am somewhat vague in my statements of distances because I was alone at the time of this examination, and had no way of getting exact measurements.

All along here were old aspen stumps and cuttings, on the left bank and in the creek bottom; on the right bank were conifers. No more indications of beaver were seen above the last of these dams except for a short distance; therefore it would appear that they have not occupied the main North Fork above this point, and indeed it is a good many years, judging from the condition of the stumps, since they lived here.

Season of 1923. On the tenth of July, the largest pond in this group, No. 2, was quite full of water, though my assistant, Mr. Mills, said there was not as much as when he saw it in the afternoon of the seventh. There was a break in the dam 34 feet long, at 61 feet from the east end. The whole mud top was broken away for this distance and apparently no effort had been made to repair it. The lodge also looked rather dilapidated and portions of the sides were undermined. (See Figs. 61, 63.)

A family of woodchucks appeared to be inhabiting an old beaver burrow in the bank of Pond No. 3.

The ponds above No. 3 on the east side of the flat seemed to be much the same as two years ago. They were full of water and evidently occupied. The canal out of No. 13 seemed to be wider and was full of water. There were trails leading up the hill from No. 15. Quite a lot of grass was floating in the water near the end of the dam here, also some stalks of lupine. As was afterward ascertained, there were muskrats in this pond and they may have been responsible for the grass.

At the end of the highest part of Dam No. 3 a lodge had been built in the dam, with an entrance into Pond No. 2, which was exposed at this date, July 10 (Fig. 59). The top of this lodge was about two feet higher than the dam.

Fig. 64 (5057). North Fork of Elk Creek. Pond No. 3, partly drained, from the westerly end of its dam, showing uprooted spruce trees and burrows in the bank. Note hillside stripped of aspen. July 21, 1921.

Fig. 65 (5058). North Fork of Elk Creek. Canal and trail from Pond No. 2, leading to Pond No. 5 (westerly series; see Map 9). Man standing on dam where trail crosses it. Mixed lodgepole pine, aspen and Douglas fir woods. July 21, 1921.

Fig. 66 (5059). North Fork of Elk Creek. Pond No. 5, showing some of the large aspens recently cut, and lodgepole pines dying as the result of submerging. View out to Pond No. 2 beyond. July 21, 1921.

Fig. 67 (6007). North Fork of Elk Creek. Pond No. 10, from the northwest, at edge of flat. Dense growth of mixed woods, lodgepole pine, aspen and Engelmann spruce. July 12, 1923.

When crossing on Dam No. 1, July 12, small trout were seen in a pool where the stream flows through the dam. Later, when watching beaver in Pond No. 2, trout were observed continually jumping there.

Above Pond No. 2 the dam at No. 4 had been extended and the pond considerably enlarged. A canal 20 inches wide and 8 inches deep now connected this with Pond No. 5, and a good volume of water was flowing from the latter to the former. Pond No. 5 seemed to be much the same as in 1921, while Pond No. 6 seemed to have practically disappeared.

Pond No. 7 had changed much. The dam was some 60 feet long as against 40 feet in 1921, and this lengthening of the dam had resulted in a much greater increase, comparatively, in the size of the pond. Off to the eastward of this were three small ponds, all new work. One of these was somewhat peculiar in having a fallen log extending along one side past the end of the dam, and mud had been piled on the five feet of this nearest the dam to hold back the water. Separate canals now extended from No. 7 up to Ponds Nos. 8 and 10. Pond No. 8 was considerably enlarged, while No. 9 was much filled up, as formerly.

At Pond No. 10 the greatest surprise awaited me. It was enlarged so as to be entirely unrecognizable (see Map 10 and Fig. 67). The dam had been lengthened from 115 feet to 242 feet, while the pond was correspondingly enlarged, so much so that it now covered part of the former Pond No. 11. In the pond, toward the south side, was a lodge which appeared to be about 15 feet in diameter, and 4 to 5 feet high above the water level. It was built about a clump of alders, of which I counted ten stems 3 to 4 inches through, also a single aspen, 3 to 4 inches in diameter, which made a marked contrast to the alders, standing erect while the latter leaned outward in every direction.

About a hundred feet easterly from No. 10 was a series of four small ponds which had been made since 1921. These had dams varying from 20 to 50 feet long and none was of any great depth.

Up the stream, above Pond No. 12, no less than six new ponds had been built since 1921, and one of these, the next above No. 12, was of very good size, with a dam 125 feet long. The next succeeding one was smaller, though still of fair size, while the other four were quite small.

Down about the older ponds, such as Nos. 2 to 7, practically every green aspen had been cut. One lone living tree still stood in the grove west of Pond No. 2. All the others were gone, also those above. It was from about Pond No. 10 and farther upstream that the beavers were now getting their food supply. The animals had been doing much cutting about here, and there were many trails where sticks had been dragged down. There were still a good many aspens accessible, probably enough for another season. Many of these trees were of large size, 10 to 12 inches through, and more, and a considerable number of this size had been cut.

On August 17 I paid my last visit to this group. Cutting was still being done on the hill above Ponds Nos. 13 to 15, a number of trees having been felled in the preceding three weeks. Several small dead aspens had been cut into.

The break in Dam No. 2 was almost repaired, and the water in Ponds Nos. 2 and 3 was much higher, standing at the same level in both ponds because of the connection through Dam No. 3. In fact there was more water in Pond No. 3

than I had before seen there, even in 1921. This would indicate that Dam No. 2 had been raised in the past two years. I would surmise from the fact that this recent repairing had been done that the beaver intended to winter here, though where they will obtain their food supply I do not see, unless they bring it down from Ponds Nos. 13 and 15, cutting the trees on the hill above there; also perhaps using willows. Food might also be brought from Pond No. 10, and those above. The ponds below No. 2 were covered with grass and small willows.

I examined the lower part of the stream where there are so many old dams, and where in 1921 a few new ones were located. These last were all gone, and no trace of them remained. I was not at all surprised that such was the case, for there was no food for the builders excepting a few small willows, and no incentive for the dams to be kept in repair.

There were three ruined bank lodges above the highest of the old dams. These I had seen in 1921, but had not examined them, and I thought it might be worth while to do so. They were close together on the right bank, and were all built over the widened mouths of burrows. The first, or most northerly, was a pile of sticks over the burrow, and was 8 feet long by 3 wide. A burrow extended into the bank behind the pile of sticks. The middle one was evidently the same sort of structure, but the sticks had all settled down so that the pile was not as large, and the burrow had caved in for several feet above it. The third was by far the best preserved. It was 12 feet long, 6 wide, and the highest part 5½ feet above the bottom. It appeared to have settled very much, and the sticks seemed to have been placed directly on the ground for at least 2 or 3 feet back from the pond's edge. There was much earth on the top of this lodge.

THE CRESCENT HILL POND SERIES

Season of 1921. What I have called the Crescent Hill group of ponds is located in the little valley between Crescent Hill and a low hill or ridge to the east, with a series of small ponds extending a considerable distance down the open valley below the largest and uppermost pond (Map 11). The little stream is fed by springs and makes its way into the North Fork of Elk Creek. The slopes on either side of the large pond are quite steep; and that on the west, or Crescent Hill side, has a considerable amount of slide rock (Figs. 68, 69), with a heavy growth of Douglas fir growing around and above the bare areas. There are dead, but no living, aspens along the shore. The hill on the east has scattering clumps of the Douglas fir, mostly good sized trees, besides some old aspen stumps. Around to the northward this hill connects with Crescent Hill by a low divide, though the valley extends up for some little distance rather steeply, and close to the Crescent Hill slope. A small spring run was found in the valley the latter part of July. As no other source of water is visible for these ponds, they are presumably supplied by springs in the large uppermost pond, although of course the melting snows in spring afford a temporary supply.

Although I began my examination and survey of this group of ponds at the lower end, and numbered the ponds consecutively upstream, it is perhaps best to begin the description with the upper and most important of the ponds, No. 14. This pond is formed by a dam 165 feet long extending from the southern end of the hill on the east, across to the foot of the opposite slope. The dam is an old

one, as is evidenced by the appearance of the sticks on the lower face, which show they have been there a long time, and by the fact that the face is so overgrown with tall grass the sticks are almost hidden. The dam was 4½ feet high and 10 feet wide across the base at the trail which crosses it. The western 29 feet of the dam parallels a canal 3 to 4 feet wide and 18 inches deep, presumably made to float logs. That the pond is an old one is shown by the fact that it contains much aquatic vegetation, such as *Potamogeton* and crowfoot. Some parts of it are choked up with the dense growth of the plants. The pond in the main appeared to be shallow, so far as could be judged by looking down into it from the hillsides, but from the hill on the east a deep, crooked channel could be seen. It extended almost to the east shore, then turned toward the middle of the pond, and then back toward the east shore again, near the end of the dam. Though the dam is comparatively short, the pond is of considerable size, approximately 800 feet long by 340 feet in greatest width. Figure 69 shows the extent of the pond, and the small lodge and dam.

Along the west shore of the pond are dead, partly submerged willows and many old floating sticks discarded by beaver after the bark had been eaten (Fig. 70). Similar floating sticks are also to be seen in the north end of the pond. On the shore at this end, for some little distance away are old aspen stumps, the most distant being 220 feet from the water. There had been no trees growing farther away. Near the west shore, toward the south end, is a grassy island, while nearer to the dam is a good sized lodge; and there is also a smaller lodge in the north part of the pond. Both of these lodges were pretty thoroughly covered with sticks.

On July 22, as my assistant, Mr. Spackman, and I were seated on the east bank opposite the large lodge, a beaver repeatedly came out, swam about for a minute or two and then went in again. This was at 12:15 p. m. After I had finished my lunch I took my camera and stationed myself on the shore near the house. The beaver soon appeared and an exposure was made. The noise of the focal plane shutter did not seem to disturb it, but the sound of tearing off the paper tab of the film pack caused it to dive. I moved closer, and after a little waiting was afforded another opportunity. This time the noise of the shutter was evidently too much for the wary beaver, for it dived with a tremendous slap of its tail, spattering the water in every direction.

The ponds and dams below this large one were all very much smaller and in two groups, conforming to the topography. The upper seven were immediately below the large pond, and were considerably older than the lower group which was separated from them by a considerable open grassy swale where there were no dams. Below the upper dam there is still a fairly steep slope on the west side, while on the east the valley widens and there is a much more gentle grade. The valley also swings much more to the eastward here.

The first dam below the large one, No. 13, is old, with the lower face well grass-grown, and old aspen sticks on the face. It was 3 feet or more high, and 6 feet across the base. The upper half of the space between it and No. 14 was filled with swamp grass, with some dead willows. The pond was quite shallow. Dam No. 12 was but a short distance below No. 13, and was likewise an old structure. The pond was narrow and shallow, with grass above it to the base of the other

dam. In the dam were two large aspens which had been felled. One of these had been cut twice, the lower cutting extending all the way around the trunk, the upper made from one side only, and the tree broke and fell away from this cut. Dam No. 11 was about 100 feet below No. 12, and was the last of any considerable length — about 60 feet long — in this upper group, and it was also the last of the older structures. On the westerly hillside were a number of aspens, some of good size, and several had been felled. There were well worn trails extending from the pond up to the trees (Fig. 71). The pond was very shallow.

Ponds Nos. 7 to 10 were all small and comparatively new ones, scattered along the shallow valley over a distance of 200 feet below No. 11. Here the ground was covered with swamp grass, and the ponds were small and triangular. Presumably their main value was in affording a waterway in going back and forth to the new works below. It is approximately 350 feet between Dams Nos. 6 and 7, and the ground was covered with swamp grass, with a few low willows. This swampy area is narrow for the upper third of the distance, the lower two-thirds being from 50 to 80 feet wide.

Dam No. 6 was located where one would naturally select a site for such a structure, as the hill on the west was still quite steep, while the slope of the ground on the east became somewhat more inclined upward and there was a slight narrowing of the valley here, so that a comparatively short dam would flood a considerable area. The westerly end of the dam was anchored against a large rock. When the survey was made, July 22, the dam was about 60 feet long. Dam No. 5 was 63 feet long, forming a sort of support to No. 6. It was about 40 feet below the latter, and about half the space was covered with grass. The four remaining dams were strung out over a space of 90 feet, and were small. All these six dams were constructed of mud and grass.

Close to these lower ponds are groves of aspens, which are undoubtedly the reason for the beaver working down here, so far from their large pond with its lodge. In one grove opposite Pond No. 6, 95 growing aspens were counted, and in the grove about the ponds and in the valley below were 163; only a few of these had been cut. Farther down the ravine were plenty of aspens, so that there is a good supply of food available here for the beaver, enough for a number of years.

This group was visited for the last time September 4. The water in the large pond was found to have dropped nine inches below a mark which I had made on August 2. Pond No. 13 had some water in it, but all the others down to and including No. 7 were empty. Dam No. 6 was found to be 70 feet long, and the pond was full of water, while the pond below had fallen four inches. Dam No. 6 was 30 inches high and the water in the pond at the dam was 18 inches deep. Five trees had been cut in the grove on the east side, and four about Pond No. 5.

The emptying of these ponds puzzled me somewhat, for the dams were still intact, and had nowhere been cut. There had no doubt been a failure of the water supply to the large pond, but why some upper ponds should be dry while those below still contained water seemed strange. Pond No. 6 being full would suggest that there were springs at this point, perhaps an underground flow.

Fig. 68 (5070). Crescent Hill pond series. Looking up the little valley from the south to main pond, No. 14. Crescent Hill slope on the left, covered with Douglas fir. July 22, 1921.

Fig. 69 (5071). Crescent Hill pond series. View down the valley from head of large uppermost pond. The conifers are all Douglas fir. The aspens have been used up along shore at right. July 22, 1921.

Fig. 70 (5069). Crescent Hill pond series. West shore along the large pond, No. 14, showing willows killed by flooding, and discarded floating sticks. July 22, 1921.

Fig. 71 (5112). Crescent Hill pond series. Beaver trails at Pond No. 11, leading to aspen grove on west. Some large trees already felled. Aug. 2, 1921.

Season of 1923. I made my visit on July 25 to the Crescent Hill colony with considerable curiosity, for knowing what the conditions with regard to the food supply were on my last visit in 1921, I thought it quite possible that great changes might have taken place. There was a decided change, but a quite unlooked-for one, which will be mentioned later.

As there was a fair supply of aspens at the lower end of the gulch I thought it possible that the beaver might have established themselves there, but such was not the case. From all appearances nothing had been done since I had last seen the place. No more of the aspens had been felled, though one which had been partly cut, perhaps two years ago, had recently blown down, and beavers had cut off part of the top. Some of the ponds were empty, none was really full, and none showed any signs of use.

Going on to the upper and largest pond, No. 14, I found the water in it rather low, but the lodge was in repair and numerous peeled sticks in the water round about indicated that it was inhabited. Because of the low stage of the water the house was nearer to the shoreline than formerly. Also the grass on the west shore above the dam appeared to be thicker and to have established a firmer sod. The grassy island, once half under water, looked very solid.

The beaver were obtaining the aspens, whose discarded portions I saw in the water, from rather high on the hill west of the dam. They were going up over the slide rock for them and had made a well defined trail. The dead logs which this trail crossed showed where sticks had been dragged over them, breaking away the half rotten wood. Below the dam was a canal, with fresh mud on its banks, extending to the pond below, whence a trail led up the hill to the southwest where there was a small aspen grove on a bench. Here a few trees had very recently been cut.

On the west shore northerly from the lodge, were a number of trails in the grass. I could not discover, however, that any bushes or other vegetation had been cut near these trails. Farther up the west side some rose and other bushes appeared to have been removed by the beaver.

The change to which I have referred was in the food. To my great surprise the beavers had been eating much bark of the Douglas fir which grows about the shores of the pond. The trees were attacked in two different ways. The smaller ones were felled, the tops and branches apparently cut off and carried away, and the bark eaten from the trunks as convenient (Fig. 129). In all cases the thick, rough outer bark had been gnawed off and discarded, and lay on the ground under and about the trees and logs. The largest trees were attacked in the following manner. The rough outer bark, often an inch or more thick, was cut away, exposing the inner layer next the wood, and this was eaten. Some trees were nearly girdled in this way. One standing tree 6.2 feet in circumference, had the bark removed all around, except a space 1.4 feet wide, and the bared space was 12 to 18 inches high, presumably as high as the animal could reach (Fig. 132). A tree 30 inches in diameter had only a width of 10 inches of bark left, and the animals had scraped the earth away about the base of the tree and eaten the bark from the roots thus exposed (Fig. 131). Others of the large trees had bare places upon them where the bark was eaten away, without being seriously injured. One tree showed especially well the manner in which the work was done. The outside bark

had first been removed over a considerable area of the trunk, exposing the inner layer, and a portion of this last had been eaten, in turn exposing the wood. (See Figs. 130, 133.)

Near the southeast corner of the pond a tree averaging 6 inches in diameter had been cut. The log, stripped naked, was 16 feet and 4 inches long. The rest of the tree had disappeared. The annual rings showed this tree to be 55 or 60 years old. Another tree close by was 5 inches in diameter, and the bare log 11 feet long; as in the other case, the remainder of the tree had disappeared. This was all fresh work.

On the west side of the pond was a log 39.5 feet long from a tree 15 inches through, having 75 or more annual rings. This was quite fresh. Another tree near by was 13 inches in diameter, but not cut so recently. There was a group of felled firs, 6 to 14 inches in diameter, all of which had had the bark eaten from the trunks, the discarded outer bark lying about beneath them, and the animals' tooth marks plainly discernible upon the wood. One trunk was 13 inches through at the butt, 5 inches at the small end, and 37 feet long. What had been done with the missing portions of any of these trees I could not tell. I saw nothing of them about the pond.

On the east side, toward the north end, a 12-inch fir tree was cut half through. There was also a freshly cut tree 5 inches in diameter. The stump, about a foot high, had the bark eaten clean off. The trunk was peeled for 15 feet, and cut half through, 10 feet from the butt. The top was still there. Another 12-inch tree was half girdled.

Nowhere else have I seen conifers attacked by beavers and so much of the bark apparently eaten. In the Longs Peak region in Colorado the lodgepole pines had patches of the bark removed and supposedly eaten, but, though some pine trees of various sizes were felled, their bark was never utilized.

It seems to me that the inhabitants of this colony, which is evidently an old one, finding the supply of aspens running short, and being loath to leave their home, the home of their ancestors, I am tempted to say, had made use of this somewhat unusual food in order to put off the day which must inevitably come when they would be compelled to move and seek a new residence.

BEAVER COLONIES IN NATURAL PONDS

The Yellowstone beavers like those in other regions often make use of natural ponds having no visible inlet or outlet and sometimes far removed from streams. Some are frequented only during their summer wanderings. Others, where there are aspen groves along the shores, are colonized for a time, until the easily accessible aspen is destroyed, then they are abandoned. Several such ponds were examined during this investigation in 1921 and 1923, and the following notes are descriptive of three typical examples, one below Yancey's ranch and the others northeast of Crescent Hill.

Yancey Pond. Perhaps three hundred yards below the Yancey barns, in a steep rocky gulch to the right of and a little above Elk Creek, is the natural beaver pond mentioned above (Fig. 72). It is closed at the farther end and has no visible inlet. There is no dam at the outlet, and at the time of my first visit, July 23, 1921, there

Fig. 72 (5077). A natural beaver pond, now abandoned, in a gulch between steep, rocky slopes opening toward Elk Creek, below Yanceys. July 23, 1921.

Fig. 73 (5230). An abandoned beaver pond at mouth of the narrow ravine through which the North Fork of Elk Creek empties into the main stream, below Yanceys. Basin filled by inwash of gravel. Aug. 3, 1921.

Fig. 74 (5056). The large natural pond northeast of Crescent Hill, occupied by beaver. The cutting of large aspens is proceeding in the groves at left and on opposite shore. July 30, 1921.

Fig. 75 (6093). The natural pond northeast of Crescent Hill. View north across the pond from between the two south groves, showing new lodge. Abundant young growth of aspen in foreground. Aug. 9, 1923.

was no water flowing through it. This pond is about 100 feet wide at the lower end, by 300 feet long, and there is a wide zone of swamp grass constricting the water into pools. Near the lower end was a small lodge, but both lodge and pond were now unoccupied.

I again examined this little pond in the gulch on July 9, 1923. There seemed to be more grass growing in it than in 1921, and I saw no signs of beaver in the pond. However, when we had left this place and started up Elk Creek we came to a sort of combination beaver ditch and trail from the creek which had lately been used, and which led toward the pond. It had evidently been occupied for a time by a small colony, but is now only visited occasionally by wandering beaver.

East Crescent Pond. Northeast of Crescent Hill, across the divide connecting it with the low hill on the east, is a natural pond with no apparent inlet or outlet, which we estimated to be about 400 yards long by 150 wide (Figs. 74, 75). It was examined July 20, and again on August 4, 1921. The trail from Yanceys to the Yellowstone River lower down passes close by this pond. There are aspens growing at the southern end of the pond, and also on the western shore, and beaver had recently cut trees at both these places. There are some islands with rushes at the northern end, and a small lodge on one of them. The water in this pond has been raised by some unknown agency sufficiently to flood and kill good sized trees growing about the shores; the rise in level seems to have been about a foot. There is no indication as to the source of supply of the water in the pond, but presumably it comes from springs.

I again visited this natural pond, situated northeasterly from Crescent Hill, on August 9 and August 18, 1923, and found that it was still evidently the home of a thriving colony of beavers. The first thing which attracted my attention when I came in sight of the place was a new lodge out in the pond away from the islands of rushes, though not far from them. In 1921 there was but a single small lodge, located on one of these islands.

There are aspen groves around the south and west sides of the pond, and one at the northerly end, all close to the water, with other larger groves a little farther away. The trees in these nearest groves are almost all large ones, 10 inches or more in diameter; in fact I think the majority are above 12 inches, and many even larger. Here the beavers were now actively engaged in cutting, and there were a number of felled trees whose leaves had hardly begun to wilt. I have never seen any other place where so many large trees were cut.

Various trails led from the water to the trees, and there were a few short canals. One of these trails was especially conspicuous as it ran through tall grass which grew almost to the water's edge. At other trails on the easterly side of the pond the beavers had cut grass and carried it away.

There were various noteworthy things among the tree cuttings. A standing, partly severed and dead aspen, 18 inches across the cut, had been gnawed all around except for 5 inches (Fig. 76). The greatest height of the notch was 11 inches, and the bottom of the notch was 10 inches, above ground. It was cut into from 2 to 7½ inches, and the core was 7 inches thick at one place. The tree had evidently been dead a long time, but the cutting had been done within a year.

One fallen aspen had three notches on the lower side, and the wood had been cut into on one side along a space of 30 inches, and to a depth of from one to

two inches. One 15-inch tree had broken when cut nearly through, and the butt was two feet above the cut and three feet above the ground. Another tree 22 inches in diameter was cut into a short distance on one side. The heart was unsound and it then broke. The leaves were still green.

Many of the large fallen logs, where suspended by stumps or top branches a foot or two from the ground, had the bark gnawed off the under side. No outer bark was found under any of these logs, indicating that it was all eaten. Under one such log the long grass was trampled and muddy. Several trees had been cut so that they had lodged on other trees and now leaned across each other. Cutting one or two of the trees which held them would release them all, but the beavers do not seem to have sensed that possibility. There were at least two separate examples of this lodging of severed trees.

At the north end of the pond were some felled trees which one at first glance might say indicated much intelligence and thinking on the part of the beaver. Two green aspens growing from the same root were cut and fell in opposite directions. A short distance away from them toward the pond, another aspen had been cut and felled. Almost at the water's edge had stood a huge dead aspen, 27 inches in diameter, the largest I have ever measured. This had been cut into a little from the shore side, and was so rotten that it had then fallen of its own weight up the hill, and landed squarely between the twin aspens and over the third (Fig. 77). A superficial examination by one believing in the ability of the beaver to reason might make it appear as if the animals had felled this dead tree after they had cut the others partly through, and caused it to fall just where it did to save themselves the trouble of completely cutting the others. However, the green aspens were actually cut before the other, for their trunks bore no marks to indicate that the dead tree had fallen between them while they were standing. They had been cut after the leaves had come out, probably since the first of June, but the leaves were much withered. Why this useless big tree was cut is something of a mystery. Perhaps it was done to prevent its falling and injuring beavers which might be at work there; or it may represent mere random, irrational activity.

At the north end of the pond the animals had not yet carried their cutting a hundred feet distant from the water, though there were a lot of aspens a little farther away.

The new lodge was of good size, at least 20 feet in diameter on the water line, and had many poles on it which appeared to be 10 or 12 feet, or even more, in length. There was a ruined bank lodge on the west side, merely a pile of sticks over a burrow.

North Crescent Pond. The following notes have been furnished by Mr. A. G. Whitney. A mile or more north of East Crescent Pond there is another natural pond that has long been frequented by beaver. Neither the pond, nor the small stream flowing through it, is shown on the government maps. It is narrow, but some two hundred yards long, and lies in a depression at the foot of a rock slide. On the opposite or west shores there were scattered Douglas firs, up to one and a half feet in diameter. The pond contains a large amount of submerged aquatic plant growth, and is a favorite haunt of ducks. Through it flows a rivulet which a short way below drops into a miniature narrow canyon extending directly

Fig. 76 (6081). Dead aspen 18 inches in diameter, cut partly through by beaver; near shore of the natural pond northeast of Crescent Hill. Aug. 9, 1923.

Fig. 77 (6139). A dead aspen 27 inches in diameter at margin of the natural pond northeast of Crescent Hill. After the cutting of several green aspens this dead tree was felled on them. An example of random activity of the beaver. Aug. 18, 1923.

Fig. 78 (5115). Tower Creek works. The large deep spring which supplies the water for this series of ponds. The trees are lodgepole pines, submerged by damming outlet of spring. Aug. 5, 1921.

Fig. 79 (5121). Tower Creek works. View across the large pond from foot of aspen slope, showing heavy Engelmann spruce stand killed by flooding. The long dam appears in background. Aug. 5, 1921.

to the Yellowstone River. On this small brook, above the pond, are many signs of old beaver work. The aspens were evidently cleared out some years ago, and the beaver have since used the stream and pond merely as a highway in their wanderings.

However, in the late summer of 1923 the beaver returned to this pond, at least long enough to make a wholesale cutting of the large Douglas fir trees on the west bank. This was noted during a scouting trip along the east and north sides of Crescent Hill with Park Ranger John Bauman about August 25. Many trees had been felled, all of them very recently, but no bark had been removed, so far as noted during a hasty examination. This cutting was very similar to that along the large pond in the Crescent Hill series, already described, but more extensive. It was the most striking example observed of what seemed to be a sudden obsession that year to cut down Douglas fir where perhaps none had been disturbed for a hundred years previously.

THE TOWER CREEK WORKS

Season of 1921. On Tower Creek, about three miles above Tower Fall, is a group of beaver ponds of very unusual interest. They are situated upon a flat along the north side of the creek, only a few feet above the level of the stream. Altogether they extend for a distance of about one thousand feet, along a space varying in width from 130 to 300 feet (Map 12). Above this flat the hillside rises rather steeply with a slope of probably twenty degrees from the horizontal. On the flat are Engelmann spruce and lodgepole pines, the former largely in the majority; also willows and a few alders. The spruce forest growth is large and dense. Over much of the flat there is a mat of dwarf blueberry bushes, with marsh grass in the wet portions. The whole group comprises twenty-five ponds of various sizes.

For about 200 feet up from the flat the hillside bears a scattered growth of aspen, the growing trees ranging from 2 to 5 inches in diameter. There are also stumps and logs of considerably larger aspens cut by the beaver. Above the aspens, on the next bench, are coniferous trees, — Douglas fir and lodgepole pine. The main growth of aspen is above the large pond. Upstream the aspens largely disappear, but downstream they continue for some distance.

This series of dams, instead of diverting water for the ponds from Tower Creek, utilizes the flow from a large, deep spring located at the base of the hill, and about 225 feet from the creek, toward the upper end of the small flood plain. This spring is now approximately 50 feet in diameter, the water being held back by a low dam 73 feet long (Fig. 78). It is shallow out to two or three feet from the shore, and then pitches off very sharply to the bottom. Where measured it was 8 feet deep, and may possibly be deeper in the center. The water is clear with a greenish tint, and there seems to be a good deal of algae in the spring. The scattered trees on the slope near by are lodgepole pines, while there are a few small dead aspens and a very few old stumps; there was one green stump, perhaps cut in early spring. A rather faint trail leads up the hill from the spring. At the southeasterly side of the spring, at the edge of the water, is a lodgepole pine 4.3 feet in circumference which the beaver have cut (Fig. 128). It lies where it fell, and no use whatever seems to have been made of it. Lying across the stump is a small spruce which had also been cut and allowed to remain where it fell.

The low dam holding back the water of the spring is an old structure, and the top is not more than 2 feet above the level of the water below. At least one-half of the top of this dam is formed by a fallen log 10 inches in diameter lying along it, and against which mud and other material has been placed. In one or two of the other dams below, fallen logs have also been utilized. If there had been but a single instance of this I might have thought it an accident, but as there are several cases I cannot but think that the beaver have intentionally used these logs as part of the dams. Next below the spring is a succession of seven dams along the flow or stream. These are all old structures, and mostly low, some not more than a foot high. On one or two, some pieces of rotten pine or spruce wood were lying up-and-down the face. The age of some of these dams is shown by the considerably decayed condition of the fallen logs previously mentioned as forming part of them.

Below these seven dams there are eight more, which spread out and cover a wider area, protecting the large pond below. Two of these dams are over 80 feet long. Most of them are old, and low, but are being kept up, fresh mud and other materials being noted along the crests. None of the ponds in these two groups appears to be more than a couple of feet deep, and many are shallower. They serve a double purpose, forming a waterway along which the beavers can travel with comparatively little danger of molestation from their enemies, and controlling the flow of water when it is highest from the melting of the winter snow, which is undoubtedly very deep here. The water produced by the melting snow, if allowed to rush down unchecked by the succession of dams and ponds, might seriously injure the large dam and ponds, — the headquarters of the colony. These dams no doubt also prevent much silt and débris from reaching the large pond and filling it up. It is also evident that in times of flood Tower Creek overflows its banks and its water submerges these ponds and dams, but is controlled to some extent by them.

The whole upper series of ponds has dead spruce killed by flooding, standing in the water, as is also the case in the large main pond below them where a heavy growth of spruce has been destroyed (Fig. 79). These large dead trees are noticeable from a distance as one approaches the ponds when riding along the hill high above.

The large pond is formed by a dam approximately 275 feet long, measured along the crest, with several pronounced curves and angles in its course, which is southeasterly (Fig. 80). The northern end is built against the foot of the hill. The dam is an old one, which no doubt has been constantly added to since its first construction, and the whole lower side is covered with layers of large sticks placed vertically up and down the face. Practically all the material comprised sections of aspen trunks and branches from which the bark had been eaten, mostly old and weathered, though the outside layer of sticks was quite fresh at the time of examination. At its northern end it is about two feet high, and obscured by marsh grass. Farther along the dam is 4 or 5 feet high, while the southern half is flatter and wide at the base, very possibly due to settling, though this portion is probably the newer part of the structure, gradually extended along from the older part to head off the water which flowed around the end. Being built slowly, a little at a time, it was perhaps made flatter. At the southern end near

Fig. 80 (5122). Tower Creek works. The long, winding dam forming the large main pond, from hillside at north end. Aug. 5, 1921.

Fig. 81 (5124). Tower Creek works. Beaver trail and slide down the steep aspen-covered slope to the main pond at the point shown in foreground of Fig. 80. Aug. 5, 1921.

Fig. 82 (5117). The huge beaver lodge, 7.3 feet high, in the main pond at Tower Creek works, from marshy shore on northwest. Some of the flooded spruce not yet killed. August 5, 1921.

Fig. 83 (6102). The large lodge in 1923, now somewhat sunken and spread out to a diameter of 33.5 by 30 feet. Aug. 13, 1923.

Tower Creek there is a shallow channel or depression, 3 to 5 feet wide, and 28 feet long. The water backs up along this, and doubtless as its level in the pond rises this channel will eventually necessitate a dam along its lower side and across the end. Tower Creek is only about 60 feet from the end of the dam, and a slight rise of the water level in the pond would turn the water out through this channel into the creek, to which a main trail now leads.

The pond is approximately 200 feet wide from the dam to the upper end, with an irregular margin, especially on the southern side, where there is no distinct dividing line between the open water and the grass land which has been overflowed. The whole area contains tall dead spruce, still standing. Many of these are of large size, and the beaver have thus destroyed a small area of good forest.

The northwestern shoreline is formed mainly by the base of the hill. It has several very well-marked trails leading up to where the animals have been cutting aspens (Fig. 81). About midway of this side is a canal, or ditch, presumably for transporting logs. It is built with two levels. Twelve feet back from the pond a sloping trail begins (Fig. 88), ending at 23 feet in a dam or unexcavated bank, and thence, on a higher level, there is open water to the end of the canal (Fig. 89). This canal is from 15 to 18 inches wide; the lower level was 15 inches, and the upper 9 inches deep. The difference of level between the two portions was 20 inches. The upper level receives its water from the marshy ground above it. On this shore a burrow was discovered which we probed for 11 feet. It sloped up the hill and was doubtless longer.

In the pond is an unusually large lodge, 21 by 24 feet in opposite diameters at the water level, and the top 7.3 feet above the water (Fig. 82). All over the outside were sticks, both old and new. Below the water level five entrances were found. The water on the side toward the dam was 4 feet deep, but shallower elsewhere. Many peeled sticks were floating in the water beside the lodge, and sunken sticks were also seen. Some fresh sticks with the bark still on them were floating near the lodge. I was able to introduce a slender stick about a foot down the vent on the top of the lodge. The house was well plastered with mud, and this appeared (on September 1) to be having additions made to it. There did not seem to be as many sticks on the top as on our preceding visits — August 5 and 8.

Below the large pond is a series of seven dams, the upper five of which extend across the flat from the foot of the slope almost to the creek. They back up the water against the foot of the long dam, the east portion of the flooded ground being fairly open water, while the remainder is much grown up with long marsh grass. Below is another dam somewhat over 100 feet long, and 120 feet down the run is a 50-foot dam. The foot of the hill comes closer to the creek here so that the flat is very narrow. There are trails up the hill from all these ponds, and along the whole succession of ponds from the spring, down, are trails across the dams from one pond to another, usually, if not always, at the channel in which the water flows over each one. All of these lowermost dams are rather low in height, and they are not recent, though evidently kept in order by the colony. They are composed chiefly of mud and grass, while in one case a large rock forms part of the dam.

Below the lowest dam is an old channel running northeastward 70 feet, where it turns off to the creek; this channel is from 6 to 8 feet wide, and had very little water running in it. It evidently once continued on a more direct course to the creek, for there is below the turn a solid filled-in space of 20 feet, and thence a continuation of the channel to the creek. At the lower side of the filled-in portion is an old dam covered with earth and stones. Possibly this old dam may have been the cause of the stream here cutting a new channel across to the creek at some high-water period, and after it was once cut a little distance above the dam the old channel below was filled with débris. At the angle where the cut-off joins the creek is what appears to be an old lodge built on the bank, while at the upper side of the channel, where it comes out at the creek, is what may be the end of an old dam. The sticks and earth are so covered up that it is difficult to tell whether they were originally a part of a dam or the remains of an old log jam.

About 200 feet farther down the stream, on the left bank, were freshly cut aspens, with a trail leading down to the bank, and in the water near by were fresh peeled twigs and leaves. The main channel of the creek was about 20 feet away. There were some old stumps and logs here, nearly all of good size, while the growing trees and those lately cut were smaller, 3 to 5 inches in diameter.

On September 6 this particular place was revisited, and it was found that more cutting had been going on during the preceding month. After an examination it was decided that the beaver, instead of living in a burrow under the bank, were housed in a log jam which is piled high at this point on the creek. On the opposite side of the stream from this there is a large aspen log, cut perhaps several years ago, the stump of which is 4.25 feet in circumference. The log was cut partly through in four places, within a space of 6 feet. The circumference between the two middle cuts was 3.1 feet. This log had been denuded of the bark. About 75 yards down the stream were more cuttings, also on the left bank. We discovered a hole beside a rock in the creek which led under a log jam, and this very likely extended up under the bank, and was where the beaver were living.

A considerable colony of beaver must be inhabiting the group of ponds tributary to the spring, how many it is difficult to estimate. The lodge alone would accommodate a large family, and a considerable number may have been living in burrows in the bank above the lowermost ponds, for the trails leading up the hill from these ponds, and the trees cut near the trails, would indicate that such was the case.

On September 1 another locality was discovered where beaver were at work, about half a mile above the deep spring, on the same side of Tower Creek, and on a similar flat above the creek bed. About 40 aspens had recently been cut here, ranging in size from 2 up to 10 inches in diameter. There were no dams, the only work being a canal. This does not extend to the creek, but between the stream and the ditch was a well worn trail 2 feet wide and 23 feet long, extending diagonally upstream from the bank, which is about 2 feet high above the water. From the end of this trail the canal runs 149 feet to its terminus at the foot of the slope, turning slightly to the right, then more at the end. It appears to be supplied with water by a spring at that end. There are some large rocks here, and the earth had been dug out about them. The ground on the downstream side of the ditch is higher than that on the upstream side, which is quite low, and

Fig. 84 (6106). The large lodge at Tower Creek works. The material piled on logs (at right) may be a separate lodge. Aug. 13, 1923.

Fig. 85 (6100). The large lodge and what are apparently the foundations of two new lodges, from near the canal, Aug. 13, 1923. The higher water has killed all the submerged spruce.

Fig. 86 (6104). The smaller of the two miniature "lodges," showing its construction. Photographed from a tree above. Aug. 13, 1923.

Fig. 87 (5248). A portion of the canal at upper works on Tower Creek, showing the banks built up of mud excavated from the ditch. Sept. 1, 1921.

in places marshy, as seems frequently to be the case in these flats along Tower Creek. Along the upper side the beaver are building the bank of the canal with mud which they have dug from the bottom (Fig. 87). In a few places the mud is also being put on the downstream bank. The width is for the most part from 3 to 4 feet, with occasional wider places due to depressions in the ground on the upper side, and dikes were being built across these. The average depth of the water is from 12 to 18 inches, but at a narrow place between two rocks near the upper end I found 3 feet of water. There were five much used trails leading from the canal to where the aspens were being cut, not more than 50 feet distant at any point.

At first sight it was difficult to determine where the beaver which were doing all this work were living; but when I noticed about 35 feet below the trail to the canal, a somewhat confused pile of sticks piled partly on the bank, I had little doubt that this covered the entrance to an occupied burrow. Very possibly this will eventually become a lodge. About 25 feet below this place was what seemed to be the beginning of a dam across Tower Creek. Gravel from the bottom had been piled up with twigs next to the bank, while farther out were sticks of various sizes evidently placed there by the animals. The whole mass pointed diagonally downstream, and did not reach more than a third of the way across. If continued it would therefore cross diagonally unless the end were turned up toward the right bank. It would be interesting to observe what the beaver would actually attempt to do in this case. There were a few old stumps on the flat, all below the canal. On September 6 this dam was found to have been extended somewhat farther into the creek. One freshly cut aspen, 8 inches in diameter, in falling had lodged against another tree, and stood leaning at an angle of about 45 degrees. Lodged on the trunk, with the butt end pointing up, was the top portion of another aspen, with beaver tooth marks on the end. One or two fair sized trees had been cut whose stumps were below this leaning tree, and it was surmised that this was the top of one of these already cut off which had been caught in some manner by the falling tree and lodged in the position in which it was found. This is worth noting as it may be the start of an effectual damming of the creek. There is a good supply of aspen available at this place, enough I should think to last a colony for a few years. The trees on the flat upstream from the canal were mainly lodgepole pines.

Near the canal I noticed an aspen, 10 inches in diameter, cut some time ago, which a wind-thrown lodgepole pine had in some manner caught and lifted up so that it is held about 8 feet above the ground. Beaver had made fresh cuts in the bark, apparently having walked up the leaning pine log to get at it.

An examination of Tower Creek above this place showed the canyon-like valley to be wider — 500 feet or more in places — usually swampy and wet toward the foot of the north hillside, with frequent springs flowing to the creek. On this bottom was a quite profuse growth of low willows, with rank grass, and a fair stand of lodgepole pine, usually rather small; there are also some alders along the creek bank. Fresh cuttings were found a mile up from the canal just described, and one freshly cut aspen three-quarters of a mile up.

Still farther up toward the junction of Tower and Carnelian Creeks some ponds were noted on the flat between the base of the hill and the creek, but owing

to lack of time these were not examined. Some old beaver-cut stumps on the bank below the game trail along which we were riding, were unusually tall, two of them measuring 3.6 feet in height.

Season of 1923. A visit to the main colony on Tower Creek on August 13 revealed the fact that not only was the place still inhabited, but that it was in a very thriving condition. The various ponds were all full of water, and considerably larger areas, both above and below the large pond, were flooded, the water spreading out over the flat toward the stream.

The lodge had been enlarged to a surprising extent, and now measured 33½ by 39 feet in diameter and 6½ feet high above the water level. This is the largest lodge of which I have any knowledge or of which I have seen any record. The measurements in 1921 were 21 by 24 feet, by 7.3 feet high. The discrepancy in height may be explained by either a difference in water level, or by the settling of the roof. From appearances I think some settling had taken place, and it was especially noticeable on the easterly side where there was quite a depression (Fig. 83). East of the lodge, and close to it, was a pile of sticks and mud on some fallen logs lying in the water. This was 6 by 15 feet by 3 feet above the water. It had one or more passages into or under it. Whether this was another lodge, or merely a shelter or refuge of some sort I could not determine. (See Fig. 84.)

About 50 feet northerly from the lodge, out in the pond, were two small mounds of sticks and mud (Fig. 85). One appeared to be about 5 feet and the other 4 feet across. Neither was more than 18 inches high above the water. I presume these to be the beginning or foundations of new lodges. If not, I have no idea as to what they may have been. I have never before seen anything quite like them, under similar conditions.

The upper level of the canal at this pond was dry. There were much used trails up the hill on the west from the pond, the one starting from near the end of the dam being very marked, and forking into three branches as soon as it reached the bench above, where the remaining aspens were located. There was fresh cutting going on among these aspens, but not as many trees had been cut there as I should have expected during a period of two years. There was still quite a supply of small food trees left at this place. Several aspens had been cut in such fashion as to be badly tangled and not yet fallen, and the beavers were able to make little use of them. They leaned over the elk trail along the rim of the bench, and animals traveling over this trail must turn out to avoid them. There was a little group of unusually tall aspen stumps here. The tallest was 50½ inches from the ground to the bottom of the notch, and 53½ to the top. Others were 41, 43 and 46 inches high respectively. None was more than three inches in diameter. I suppose they were cut when the snow was deep.

At one of the ponds a short distance above the large one a trail led through the grass to aspen saplings about a hundred feet distant. A small dam at the pond next below the deep spring had freshly peeled sticks on it, as also had the dam at the spring. At the corner of the spring opposite the fallen pine was a burrow in the bank, and on the bottom at the mouth of this were many peeled twigs. This burrow appears to have been excavated since 1921.

A lodgepole pine had been cut into a little at this place. Near the large beaver-felled pine noted in 1921, another 13 inches in diameter had been cut half

Fig. 88 (5120). The lower level of the canal, connecting with the main pond at Tower Creek works, showing the dam and trail leading to upper level (under the fallen tree). Aug. 5, 1921.

Fig. 89 (5119). The upper level of the beaver canal. The fallen tree lies on the dam separating the two levels. This level is supplied from a spring above. Aug. 5, 1921.

Fig. 90 (5125). The thicket of small aspens, largely culled, on slope near the main pond at Tower Creek works. Aug. 8, 1921.

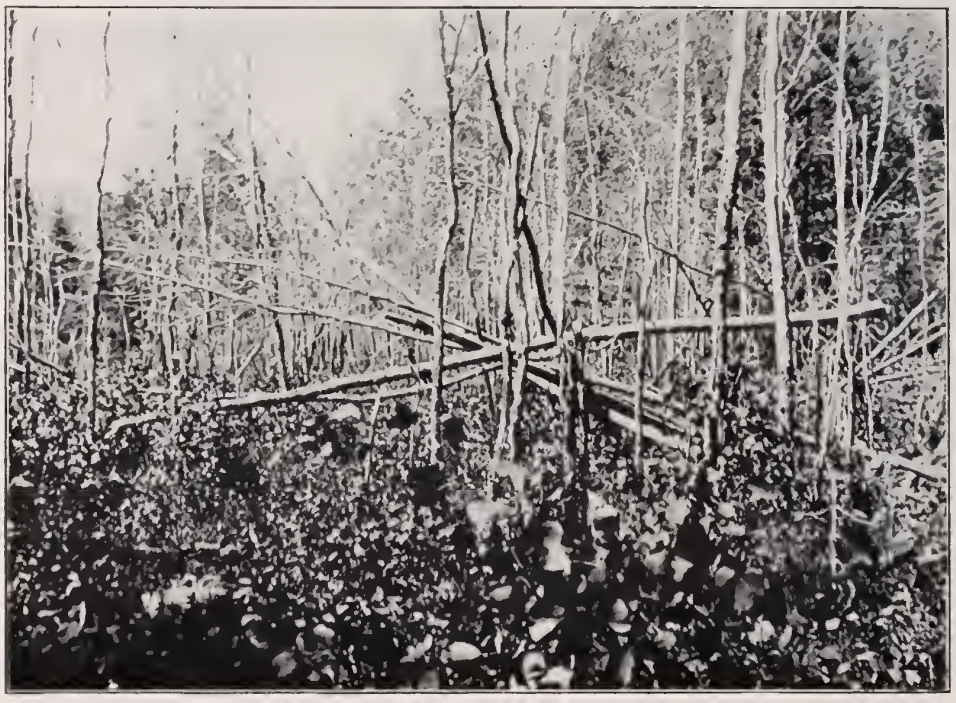

Fig. 91 (6097). A tangle of felled aspens lying across the elk trail at edge of bench above slope shown in Fig. 90. Note the heavy young seedling or sprout growth of aspen. Aug. 13, 1923.

through. A six-inch pine had been almost girdled. At the other end of the spring a pine about the same size had a large patch of bark gnawed off and a small notch cut into it. One or two other pines showed marks of the beavers' teeth. According to Mr. A. G. Whitney this work on the pines was mostly done prior to August, 1922.

At the creek, about opposite the spring, a seven-inch pine which once stood on the bank had been blown down and now lay in the water with its roots in the air, and with a large ball of earth still adhering to them. The foliage of the tree was still quite fresh. The ends of several of the roots had been cut off by beaver. This was similar to work which I had noted in the Longs Peak region, Colorado, in 1922 (Warren, '26, pp. 225–226).

Below the large pond trails led through the grass from the various lower ponds to the creek. At two places below the deep spring colony a little cutting was going on, and there were trails to the water and up the hill.

At the small colony about half a mile up the creek from the deep spring I found the canal to be in excellent repair and full of water, while the trail from it to the creek showed signs of use. I did not discover any cutting being done here, though there were trails leading from the canal.

What Dr. R. A. Muttkowski (who accompanied me in 1921) and I thought might be a lodge that year, looked much more like one at this later examination, though still a rough pile of sticks with some mud (Fig. 92). It was situated at a place where a little point extended into the stream, with large rocks at the outer end, and good-sized pines growing on it. The water swings in above it, and then out around the rocks. Some fallen logs lie butt-end against this point, and sticks also are piled on these, perhaps to form an entrance, or a sort of roof or screen protecting the real entrance to the lodge. The lodge itself is on the point between the above mentioned trees. It is a rather irregularly shaped mass of sticks and mud. Back from this, and separated by a short space with only a few sticks, were more sticks piled on the ground, probably over a burrow. The main part of the lodge measured 11 feet up-and-down the stream, and 9 feet across to the space with only a few sticks, which was 2 feet across. The other part was 7 feet long by 5 wide. I could find no traces of the dam which was begun in 1921. It was probably washed away by high water the following spring.

A quarter of a mile, or less, below this colony, some very large aspens had recently been cut on the bank. One or two must have been 18 inches through, though I did not measure them. A lodgepole pine 21 inches in diameter had been cut one-third through. At both colonies small conifers one to two inches in diameter had been cut, and their trunks were gone. These were not recent cuttings.

CARNELIAN CREEK COLONIES

Season of 1921. Carnelian Creek is a tributary of Tower Creek, which it joins from the south about four and one-half miles above Tower Fall. It is a good sized stream heading in Dunraven Pass. On the single visit which we made, September 6, there was but little time for examination, and we explored for only about half a mile upstream. In this distance considerable beaver work was found, most of it not much more than a quarter of a mile above the confluence with Tower Creek.

On a flat on the right bank was a series of four fair sized ponds. These received their supply of water from the creek in the following manner. There is a very old dam extending partly across the stream, the bed of which is quite wide here, and makes a considerable bend. From the end of this old dam, a low extension runs out part way to the right bank in such a manner as to divert a portion of the water into the upper pond, whence it finds its way on through the others (Fig. 94). The creek has such a considerable grade that the lowermost of the ponds is several feet above its level at a point opposite (Fig. 95). These four ponds appeared to cover a length of nearly 300 feet. There were well beaten trails extending up the hillside from the ponds. There are but few aspens here, and most of these are of large size. There are plenty of alders along the creek, and some willows.

On the creek itself are dams and ponds, including at least two dams which were scarcely more than begun, and had only just reached a stage in their construction where the ponds were beginning to form. These dams were built largely with willow and alder branches. One dam backed the water up the creek for 100 feet or more, and also up a wide depression on the left bank, this being 4 feet wide and 50 feet long.

Below the old dam I have previously mentioned was a new lodge in the bank (Fig. 93). It was only 15 inches above the ground level, 3 feet in diameter, and the center was 5 feet from the shore. It was covered with both green and dry alder branches. About 75 feet above this lodge, and above the dilapidated dam, was an old lodge in the bank, about 10 feet in diameter and 3 above the ground level. The sticks covering the top were very old and rotten.

Carnelian Creek is certainly worthy of more study and exploration, and I regretted that I was unable to give more time to it. To study either Tower or Carnelian Creeks without undue loss of time in going back and forth, one should camp on Tower Creek at some point from which he could work both of the streams conveniently.

Season of 1923. The following notes are furnished by Mr. A. G. Whitney. "A trip was made by horseback to the Tower Creek works and up Carnelian Creek, August 24, 1923. In riding along the Carnelian Creek, no new beaver work was noted for perhaps one-half a mile. At that point a most interesting new dam 6 or 7 feet at the greatest height was discovered, spanning the whole stream. It was about 100 feet below some minor, old works which may have been those examined in 1921, but were not recognized as such. This was the largest stream that appeared to be successfully dammed during the two seasons' observations in the Yancey region.

"The main cribwork of the new dam was barely completed, and the water was streaming through the interstices everywhere. The pond was very roily, and all signs indicated that the beaver were in the midst of operations. Any earth that may have been inserted in the dam had been washed through the crevices by the pressure of the current which was relatively strong, as the pond appeared to be 6 feet deep at the dam, and extended back for probably 75 feet. The cribwork was perhaps 40 or 50 feet long; braced at the east side of the creek channel against the high gravelly bank, and at the west side, 30 feet distant, interlocked

Fig. 92 (6110). The bank lodge at upper colony on Tower Creek, looking downstream. A characteristic view of this creek which is too large and swift for the beavers to dam. Aug. 13, 1923.

Fig. 93 (5288). A bank lodge entirely underground, on Carnelian Creek. Its location is indicated by the pile of sticks and branches on the bank. Sept 6, 1921.

Fig. 94 (5291). The diversion dam at lower Carnelian Creek colony, turning water from the stream to ponds at left. Sept. 1, 1921.

Fig. 95 (5290). The series of ponds supplied from Carnelian Creek by the diversion dam. Sept. 6, 1921.

in a clump of large alders. It ran out to only a few scattered sticks farther along, where for 30 or 40 feet the high water flowed several inches deep over the grassy flat. The natural abutment for the west end is the higher bank at the edge of the timber beyond the grassy flat; and if the main part of the dam holds at mid-channel, the whole structure will doubtless be built evenly clear across the flat. There was a tangle of old fallen trees on that side, so the water could readily be controlled there later. The critical point, because of the depth and pressure, was the main channel, and it was there that the beaver were concentrating their efforts. The cribwork was composed of a large variety of materials, — the beavers had used anything that came to hand. Willow and alder sticks, a little aspen, and even branches of the ground juniper torn from the gravel bank, were used. Most were freshly cut, some with the green leaves still attached. At the east end stones as large as one's hand had been rolled down the slope and laid along the top of the dam for a few feet out from that end. No very large branches were used in the construction, and the whole dam gave the effect of a lattice work, through which the water poured as through a sieve. If the stream had been wholly stemmed, the pressure would soon have carried it out. Perhaps it will hold permanently only if enough silt and debris come down to fill in well behind the dam by winter or before the spring floods.

"The greatest activity, but recently begun, was apparent at these works, not only in damming the stream but also in cutting a big supply of aspen. At this altitude signs of autumn were already appearing, — a hail squall passed while the observations were being made. But there was no indication of a new lodge being started. A small old bank lodge, just above the new pond, and partly washed out, was the only sign of a habitation noted.

"This upper course of Carnelian Creek lies in a deep gorge, with a steep 1,000-foot forested slope rising on the east, a narrow flat at the stream, then a heavy lodgepole pine forest sweeping up the low west slope. The flat is covered with pine, except for a few large aspens intermixed at this point. These aspens were what held the beaver colony here. They were 12 to 15 inches in diameter and very tall as a result of growing in competition with the pine. Most of these large trees had not been cut until just recently; but now the last of them were being felled. They had been cut en masse, and lay crisscrossed at all angles. They were not yet cut up into logs, nor were the branches trimmed off except in a few cases, which accounted for the dearth of aspen sticks in the new dam. This splendid grove, of perhaps forty trees or more, had been left untouched for probably 100 years, although close to the stream, and then in a week or two practically all were laid low. The ruins of old works here were negligible; and after the few large aspens are used along Carnelian Creek, within the next year or so, it is unlikely that further works will be built.

"Above the first gravelly ridge on the east, and opposite the dam, was an open meadow, several acres in extent, with thick sward and no trees whatever, though the dense lodgepole pines pressed close around all the margins. It looked like an ancient beaver meadow, though no spring feeders were now visible and there were no aspens."

OTHER BEAVER WORKS NOTED IN YANCEY REGION

Abandoned Pond-site Below Yanceys. About 200 yards below the Yancey buildings the North Fork of Elk Creek, a small stream, comes in on the left, emerging from a steep-walled, very narrow ravine. At the place where the stream comes out into the Elk Creek meadow are the ruins of an old pond and dam, now filled in with sand and gravel, with a little grass growing on the dam. This was first examined August 3, 1921, when a photograph was taken (Fig. 73). What made the pond specially noteworthy was the comparatively long curved dam. It was 45 paces around this dam. I was at the place again August 6, 1923, and with the aid of a compass found that the angle subtended between the two ends of the dam was 245°. About three quarters of the dam was curved, one quarter was straight. I have never seen another dam which covered so great an arc, if that term can be applied to such an irregular line.

At the southwestern end of the dam was found the remains of a lodge, and in the pond were old aspen stumps and a burnt fir stub. The dam must have been three feet or more in height. A mass of sticks was lying to an unusual thickness over the face, many of them 3 and 4 inches through, and though weathered, not at all decayed. It seems that notwithstanding the small size of the pond the occupants must have cut a great deal of aspen while living there, and had remained for a considerable period.

Slough Creek. Some of the guests at Camp Roosevelt had told me of seeing beaver work in a slough tributary to Slough Creek, and I looked it up. It proved to be old cuttings by the slough, which was quite a long one, probably natural, not made by the beavers. There was, however, an old dam across it, much obscured by the grass which grew clear across the slough, both above and below the dam, and also all along the sides. A number of large aspens once grew on the banks, and these were cut long ago. Two or three large cottonwoods were also cut.

In 1921 I was at several points along Slough Creek, extending over a distance of several miles up from its mouth, and found little or no fresh sign of beaver, and old work was not at all plenty.

Several ponds just west of Slough Creek were examined by my assistant, Mr. Mills, August 11, 1923. He found two ponds obtaining their water from a small stream which was nearly dry, and a canal which led from the upper pond was also dry. The water was low in the lower pond, and appeared to be still falling. About the ponds were numerous recently cut aspens. Two aspens together, 10 and 12 inches in diameter, were both partly cut.

Two natural ponds northwest of Slough Creek, also examined by Mr. Mills, had a large amount of old work about them, but nothing recent. There was a bank lodge at one of these, which was in ruins. It measured eight feet across. There was neither inlet nor outlet to these ponds.

LAVA CREEK ROADSIDE COLONY

Season of 1923. This colony, 5½ miles east of Mammoth Hot Springs, beside the road to Tower Falls, is an old one. Its history has been recorded by Mr. M. P. Skinner in his Yellowstone Nature Book, pp. 112–123. One of the ponds, situated beside the road, had long been an object of interest to the passing

Fig. 56. The Yellowstone River canyon (region of the "palisades" and "needles") just below the mouth of Tower Creek, where it is about 600 feet deep. The tree growth is wholly of Douglas fir, several of which were felled by beaver late in August, 1923, at the edge of the rapids. Photo July 16, 1923.

Fig. 97 (Haynes: 20,027). Lava Creek roadside colony. The pond as it appeared in 1920. Note the duckweed along the dam at right, and the fresh additions of mud. The drowned trees are lodgepole pines. Photo reproduced by courtesy of J. E. Haynes.

tourists, many of whom stopped to examine it, and to watch the broods of ducks that frequented it each summer. For years it had been the most striking example of an active beaver colony near the Park highway. But unfortunately the dam was broken in some manner during the latter part of May, 1923, and the water stands from 18 to 24 inches below its former level, making a muddy, unsightly slough. Its original and present conditions are shown in figures 97 and 98. Superintendent Albright informed me that the pond was full and the dam intact on the tenth of May, and that the break was made before the opening of the tourist season; just when, or how, he did not know. This pond, and all the other ponds in the colony, were deserted in 1923; but the beavers were reported active there again in 1924.

I examined these works August 25 and 27. The dam forming the roadside pond is somewhat crooked, with several angles, and a general upstream bend. The needle course across from end to end was S. 5° E., and the greatest departure from the chord was 35 to 40 feet eastward (estimated). The total length of the dam was 301 feet, the northerly end of the break being 130 feet from the north end. The break was 15 feet wide.

The course of the west side of the pond was approximately N. 30° E., magnetic, and its length .3 of a mile to the upper end of the flooded area, and .4 of a mile to the upper end of the grass covered portion. Shallow water occupied much of the area, and it was largely covered with duckweed, which appeared to be appreciated by the ducks, for twenty-two mallards were at the pond when we arrived. A kingfisher, perched on a stick projecting from the water — as if it had been placed there for the bird's especial benefit — was in the act of swallowing a fish. A spotted sandpiper was also seen, and a little later a blue heron, at a pond above.

There was a good sized lodge in the pond, evidently an old structure. At the southeast corner of the pond were lodgepole pines cut by the beavers, and also pines standing at the edge and in the water, which had been killed by flooding (Figs. 98, 99). Some of the felled trees were 12 inches in diameter and had the branches still remaining on them. Toward the upper end of the pond were willow stumps which had been cut off before that part was flooded, while grass occupied the upper fourth of the basin (Fig. 100).

The main Lava Creek enters the pond near the south end of the large dam, and this stream had seven dams on it in a distance of 350 feet above. The two or three lowermost were quite small, but some of the others were fairly long. Above these was a pond, probably eighteen inches or more below normal level, the water finding outlets through several places in the dam. A canal 76 feet long led from the pond toward the next pond to the north, but had no water in it. There was a trail 6 feet long from the canal to this pond. Its quite crooked dam measured 191 feet long around the curves, there being no water above the south 26 feet. Besides being crooked, this dam had a very pronounced downstream bend. The needle course of the part with water above it was N. 30° E., and from the same point to the extreme downstream point on the dam the bearing was N. 15° E. The pond was about 50 feet wide.

The next pond to the north had a dam much grown up with grass, and that seemed to be the case with the three or four ponds still farther north. The first

of these had an old lodge in it, on which were growing grass and moss (Figs. 101, 102). I could see no indication that these ponds were now inhabited. This series extended nearly as far north as the pond by the road, though situated at an appreciably higher elevation.

LAVA CREEK SIDE-GULCH COLONY

Season of 1923. About three miles east of Mammoth Hot Springs, in a steep rocky gulch opening north toward Lava Creek, below a sharp bend in the Park road, is an unusual series of ponds. They are probably about 150 feet below the level of the road, and beginning 100 yards or more from it, extend down the gulch, which is so narrow and steep that the dams are unusually high in proportion to their lengths. As there is no stream where the road crosses the gulch, or even at the uppermost pond, the water is probably supplied by springs.

The ponds are somewhat of a surprise as one looks down upon them from the road, and sees them nestling at the bottom of the gulch in the Douglas fir forest (Fig. 103). The upper one is the longest, perhaps 100 feet, and has two bank lodges on the right side, one close to the end of the dam, the other a third of the length of the pond above (Fig. 105). The dam was about 25 feet long, and between 2 and 3 feet above the water in the pond below, which was backed against it. The dam below was 6½ feet high, 25 feet long, and the pond was of about that width. Then came two or three smaller ponds, next a larger one with a dam nearly 6 feet high. This last had two lodges, one at the upper end, the other on the left bank. There were more small ponds below this. These were all old works, possibly just recently reoccupied by the beaver.

The inhabitants of this colony had been cutting aspens high up on the steep slope below the edge of the road, among the slide rock (Fig. 104), and dragging them over well worn trails down to the upper pond. The few aspens at this place were nearly all cut. Besides the aspens, the beavers were going after the Douglas fir trees in earnest, and had cut some which they had pretty well stripped of their bark, besides eating bark from the trunks of standing trees. The firs were small, the largest not more than eight inches in diameter. They were found right down to the water's edge, and so were much more accessible than the aspens.

BEAVER LAKE MEADOW

Season of 1923. On the morning of August 29, as we were on our way southward out of the Park, we stopped for a short while at Beaver Lake on the highway near Obsidian Cliff. This is now practically all a meadow, a half mile or more in length, with Obsidian Creek flowing through it, and a few pools of water near the dam. In measuring the ancient dam I did not attempt to follow all its angles and crooks, so that the length obtained — 1,054 feet — was really less than the actual distance, which very likely is about 1,200 feet. The dam was from two to three feet high. The creek cut through it at 276 feet from the end nearest the road. At the farther end was a pond with yellow water lilies. At one place a supplementary dam extended from the lower side of the long dam, and curved down and around, returning again to the latter, so it is certain that once a small pond was there. The ruins of a lodge could still be seen in the meadow.

Fig. 98 (6154). The roadside pond, Aug. 27, 1923, now nearly empty and deserted by the beaver. The dam had been partly torn out in May, 1923. View from same point as in figure 97.

Fig. 99 (6149). The roadside pond, showing drained conditions. The highest water level is indicated on the drowned pines. View from dam toward upper end, Aug. 25, 1923.

Fig. 100 (6146). Upper end of the roadside pond, a favorite nesting haunt of mallard ducks. The Park highway crosses center of view. Aug. 25, 1923.

Fig. 101 (6153). One of the abandoned ponds on upper works, Lava Creek colony. Water largely covered with duckweed. The scattered trees are lodgepole pine and Engelmann spruce. Aug. 27, 1923.

How long it took to build such an extensive structure we have no means of knowing, but very many generations of beavers must have been concerned in it.

A blue heron was seen here, as well as mallards, and a marsh hawk was hunting over the meadow.

LEWIS RIVER FALL COLONY

Season of 1923. On the afternoon of August 29 we camped by Lewis River, below the falls, 13½ miles from the West Thumb of Yellowstone Lake and here I found some of the most remarkable beaver work, in some respects at least, it has ever been my lot to see.

There were some old stumps cut by beaver, close to where we stopped the car, and as I walked down beside the river I saw considerable work on the lodgepole pines, resembling that which I found in the Longs Peak region, Colorado, in 1922, the bark having been removed in triangular patches (Fig. 110) as in that locality. A quarter of a mile below camp I was surprised to see a very tall beaver-cut pine stump, so tall that it startled me, though I was destined to have greater surprises before I had completed the day's work. This stump had been cut at 52 inches above the ground, this being the lowest part of the notch, and the diameter at the cut was 13 inches. Another cut had been started at 14 inches above ground, but not carried very far. In the neighborhood were more tall stumps, as well as trees with notches cut into them high above the ground. This sort of work extended down the river as far as the 14-mile post.

The stumps varied in height from 4½ to more than 6 feet, with one 8 feet, and another 8 feet and 8 inches tall (Fig. 108). I think the last must be a record for height. The highest stump was 6 inches in diameter, and the eight-foot stump measured 9 inches. The log from the former had a notch cut into it 17 inches above the butt, and the tops of both logs had been cut off and were missing. The trees attacked varied from 3 to 24 inches in diameter. One stump three feet high was found, and one less than a foot. A number of trees had notches cut into them at the usual heights, 12 to 14 inches above ground.

Where the trees were only notched the bark sometimes had been removed for a considerable space. One notch was more than 20 inches high. On another tree the cutting began at 30 inches above ground, and extended up 30 inches, and its greatest depth was 4 inches (Fig. 109). In many cases where the bark had been eaten away the wood also was cut into somewhat (Fig. 111).

One six-inch stump that was 5 feet and 9 inches tall, had two or three notches and cuttings. One cut began at 42 inches above the ground, and another commencing at 51 inches extended spirally a little more than all the way around, the highest point being 63½ inches (Fig. 112). It was the best example of a spiral notch I have ever seen. A few of the logs had had parts of the branches severed.

None of this work was really fresh, the tall stumps being the oldest, and places where the bark had been gnawed away the more recent, so that the work must have been done in at least two different years. The comparatively uniform height of so many of the stumps suggests that they were cut when the snow was about four feet deep, or a little less. The excessively high ones may have been cut where the snow was drifted. I could see more tall stumps on the opposite bank of the river, showing that the animals had been working on both sides.

I presume that these beaver lived in the banks, which, however, were not much more than three feet high. There was a quite level area 100 to 300 feet wide extending across to the road, on the other side of which the ground began to rise. This area was covered with a rather open growth of lodgepole pines, and, I think, a few blue spruces. The character of the forest is well shown in figures 106 and 112. There were no aspens, but some open meadow along the river margin (Fig. 106).

RELATIONS OF BEAVER TO TOPOGRAPHY AND STREAM FLOW

The adaptability of the beaver to the conditions of its changing environment is in many ways remarkable. In the Yellowstone it has established colonies along streams wherever its chief food, the aspen, is to be found, though the topography and water conditions may often make its engineering work very difficult. Where once thoroughly established it appears inclined to linger for many years even after the exhaustion of the aspen supply, lately even resorting to the bark of coniferous trees for food. Ponds and rivers not suitable for colonies are nevertheless continually explored by wandering beaver and utilized for temporary quarters or for travel routes.

Adjustments to Topographic Conditions. A study of the accompanying maps of the various groups of beaver works in the Yancey region (Maps 2-12) indicates much ability on the part of these animals to adjust themselves to the various conditions which they have encountered, for no two of the localities are quite alike in their topography and surroundings. A brief résumé of our observations on the various beaver works in relation to the topography is here in order. The U. S. Geological Survey contour map (Map 1) gives a fair idea of the varying gradients of the streams.

The construction of the beaver works at the Yellowstone Bridge colony, in a narrow ravine with steep slopes on either hand, resulted, after several years, in a series of small ponds, most of which are less in their dimensions lengthwise the stream than the dams forming them are long, and the latter in many cases do not back the water up to the foot of the next dams above (Map 3). Also, as a result of the steepness of the ravine the ponds are rather shallow, and the distance covered by the works is relatively short. The small size of the ponds has apparently operated against the construction of lodges in the water away from the shore. The two existing lodges are built against the banks, into which a number of burrows also have been tunneled.

On Upper Lost Creek we again have a comparatively narrow ravine with steep slopes on both sides, but differing decidedly from the preceding colony in having less fall with a greater width of bottom land, so that the stream, instead of flowing in a quite direct course along the bed of the ravine, meanders from side to side. This stream is also considerably larger than the other. Here also is a long succession of dams, the great majority of which, however, are old and abandoned (Map 4). It can still be determined, however, that the ponds formed by these dams were proportionately much longer up-and-down the stream on this creek than those near the Yellowstone Bridge. Some were built where the stream was approximately in the middle of the valley, others at one side or the other.

Fig. 102 (6152). Detail of shore of upper pond shown in figure 101, with lodge and canal. The trees are spruce and pine, over thick ground cover of marsh grass and herbs. Aug. 27, 1923.

Fig. 103 (6156). The Lava Creek Side-Gulch colony, from the bend in road crossing head of gulch. The upper ponds among Douglas firs at foot of rock slide. Mammoth Hot Springs in distance. Aug. 27, 1923.

Fig. 104 (6158). The few remaining aspens now being cut at top of high rock slide, close to road, near Lava Creek Side-Gulch. Note felled aspen completely stripped of branches. The road is at upper right. Aug. 27, 1923.

Fig. 105 (6159). The upper ponds at Lava Creek Side-Gulch. Works recently re-occupied; aspen about exhausted, and Douglas fir now being cut extensively. Note freshly felled fir above bank lodge at right. Aug. 27, 1923.

according to the meanders. There are still several dams in use, and they are not new, though well kept up. The reason for this is to be found in the food supply of aspens yet to be obtained close by. Here the conditions are favorable to the construction of lodges out in the water away from shore, and there were in 1921 three, and in 1923 two of these in the largest pond. Burrows are likewise present. About the abandoned ponds ruins of lodges were found against the banks, and one against the upper side of a dam, indicating that in those particular places the beaver could not make the other type of lodge. At the occupied ponds the water is backed up to the dams next above, due to the slight grade of the stream. In both the Yellowstone Bridge and Lost Creek colonies nearly all the dams are built entirely across the ravine itself, with their ends against the hillsides, thus taking advantage of all the ground and securing a good anchorage.

On the North Fork of Elk Creek there are different topographic conditions. The stream is in a fairly wide valley with a variable grade, and with a steep slope on one side only. Here also are abandoned and occupied dams. The former were not carefully studied, but in most cases they had one end resting against the hillside on the east, while the other end was presumably carried far enough out on the comparatively flat ground on the west to control the water. At the occupied ponds the gradient of the valley is such that the ponds are quite narrow in proportion to the length of the dams. This group is unique in having two divergent series of dams above the largest pond (Map 8), in which latter there is a round lodge. One of these two series is a succession of small ponds built along the stream itself, which flows along the western side of a wide flat. These ponds are presumably constructed to afford a waterway for the animals to travel along, for the transportation of food, and also to give protection against floods in periods of high water. Certainly no beaver were domiciled in them in 1921. Over on the easterly side of the flat is a quite different situation, where, apparently without any stream and with only the seepage water from swampy ground, the beaver have built two long dams and made good ponds above them, besides smaller dams and ponds. Here they appeared to be actually living and making fuller use of the aspens growing near by. Here also, in spite of the fact that there was a smaller water supply than the stream afforded, the opportunity for making large ponds was better than on the creek, because there seemed to be somewhat less slope to the ground and the dams could back the water up farther; nor was there any danger from spring floods. I think also that the soil was more easily excavated in order to build dams and deepen the ponds. It appeared to be much more free from stones and gravel than on the west. Quite possibly this may have been a factor as well as the food supply, in inducing the animals to work here, for there was still a fair number of aspens on the other side.

Crossing the ridge to the South Fork of Elk Creek we find quite a different situation (see Map 6). Here is only a small stream, with a flat sloping gently to the north. In some respects it is not unlike the easterly series on the North Fork. The principal dam, evidently quite old, seems to have been built gradually, and added to from year to year, judging from its irregular shape. The beaver here also have utilized the seepage water from swampy ground.

The Elk Creek Bench colony, between the two main forks of Elk Creek, is another example of utilization of water from springs and bog areas, the flow in

this case scarcely equalling the evaporation and seepage from the ponds. The topographical conditions favored the formation of a much larger and differently shaped main pond than on the South Fork, through the building of a comparatively short and low dam, at the downstream edge of a broad level flat. In 1921, canals had been cut, connecting two of the small upper ponds with the larger one. By late July, 1923, the water in the main pond was gradually diminishing and the expanding ponds above, to which the beavers were now transferring their living quarters, were taking all the flow from the springs in the spruce bog just above. The large pond was therefore evidently abandoned for lack of a water supply, notwithstanding its large lodges and the abundance of aspen close by.

At Crescent Hill the beaver took advantage of the natural depression between Crescent Hill and the low hill to the east, and by building a short dam at the lower end formed much the largest pond in the region (see Map 11). The water is presumably supplied by springs within and a short way above the pond. The ponds immediately below, in open areas chiefly, were seemingly for protection and transportation. The construction of the newer series a little farther down the valley had not progressed far enough in 1921 to show definitely what the final outcome would be, though the beaver were evidently after the aspens growing at the lower end of the series, and, as previously remarked in the account of the group, one dam is very advantageously located for making a large pond. Yet this lower section had been abandoned, at least temporarily, in 1923.

The conditions on Tower Creek necessitated a very different sort of construction work (see Map 12). The stream bed is quite wide between banks, with a fairly steep gradient, and doubtless in spring and early summer, when the snow is melting, a turbulent flood fills it and even overflows the banks, powerful enough to destroy any dams the beaver might build across the creek. Therefore they have made use in places of considerable areas of fairly level flood plain, a few feet higher than the stream, with a water supply from springs and swampy places, rather than from the creek. While but one group of dams and ponds — the only extensive series — was surveyed and mapped, other similar ones on a small scale were noted from the game trail along the side of the canyon. These minor works were not studied for lack of time. The series mapped is one of the most interesting in the Tower Fall-Yancey region, and perhaps the most striking of all. When one looks at the map of these works he cannot but regret the lack of the complete history of the construction and succession of the dams. Presumably the long dam, now kept in the best of repair, was one of the earliest if not the first to be built, and the others above and below were built as circumstances required. Perhaps a study of the other groups on the creek may give a clue to the early stages in this progression.

The conditions on Carnelian Creek are somewhat similar, so far as observed, to those on Tower Creek. The diversion dam there was an interesting bit of engineering and a good example of the beavers' ability to accomplish their objects under varying and accidental circumstances. A complete survey of Tower Creek may disclose like devices on that stream, which obviously is too strong and swift, especially during freshets, to be successfully spanned by beaver dams. On upper Carnelian Creek, a notable attempt was being made in 1923 to completely stem the stream, and with apparent success.

Fig. 106 (6165). Cuttings in heavy lodgepole forest below Lewis River Fall. Stump 6 feet high; butt end of log showing at right. Lewis River and meadow beyond. Aug. 29, 1923.

Fig. 107 (6166). The log from stump in figure 106, 15 inches in diameter at the butt. Note the very narrow kerf. Aug. 29, 1923.

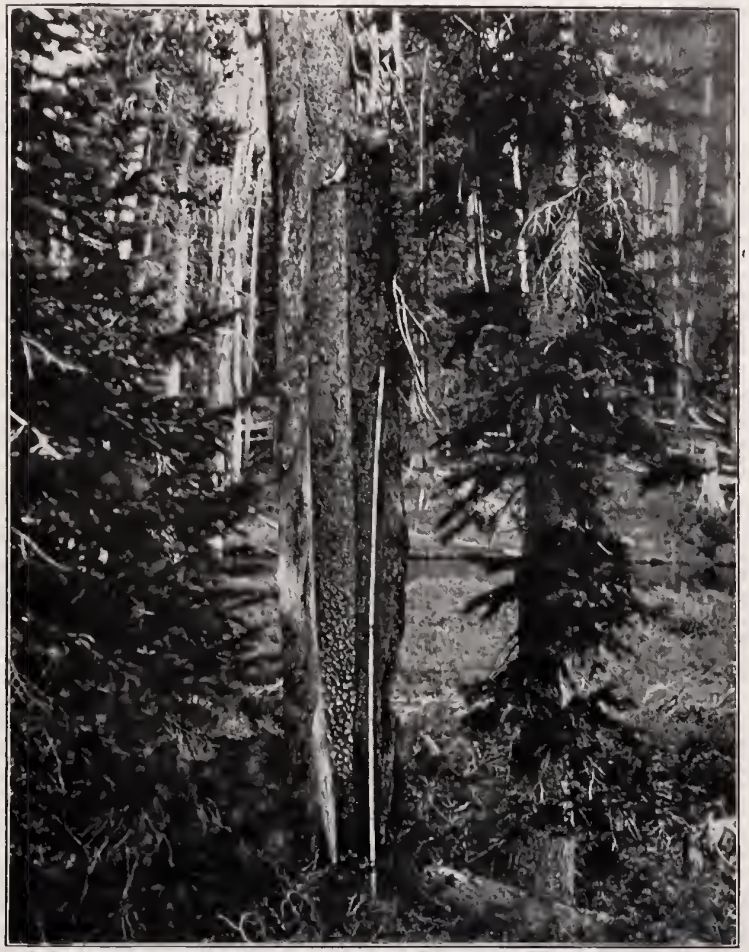

Fig. 108 (6172). The record stump along Lewis River, 8 feet and 8 inches high, 6 inches in diameter. (The rule is 6 feet long.) Spruce and pine in mixture here. Aug. 29, 1923.

Fig. 109 (6173). An 18-inch lodgepole pine with an unusually long notch, beginning 30 inches above ground and extending upwards 30 inches; 4 inches deep. Aug. 29, 1923.

At Lost Lake (Map 5) there is considerable doubt as to what degree the beaver are responsible for the present-day conditions. True, there is a dam across the lower end, but this seldom needs repair, as the outflow is negligible, and it is not necessary for the formation of a pond. The water is unusually deep in the central part of the lake where the animals live; and there must have been nearly as large a pond before the dam was built, with perhaps springs in the deep portion to supply the water, and certainly at the upper end of the lake on the forested slope. The life of the beaver here — and in such natural ponds as that to the northeast of Crescent Hill — would seem to be much less strenuous than for those living where dams are necessary and require continual care, and where an intricate system of ponds and canals has to be dug; but on the other hand, the available aspen is gone, and water lilies and the bark of conifers comprise about all the food remaining.

The works below the Petrified Tree Road are an example of the utilization of a small stream flowing gently through a rather wide valley. The beavers had no particular difficulties to overcome, except perhaps the necessity for the construction of one or two quite long dams, and that really does not appear to be any difficulty to them. In some respects it seems to me to have been the most favorable location for a beaver colony in the Yancey Region, with the possible exception of the Yancey Meadows. So they have a somewhat extensive series of ponds, some in use and some abandoned, with lodges. In 1923 they were busy harvesting the last of the aspens.

At the natural pond northeast of the Crescent Hill Colony the animals had little or no occasion to display their engineering abilities. The pond has neither inlet or outlet, and the water level is probably fairly constant, varying but little. They built lodges out in the pond, well away from the shores, which made them safe from molestation. There were plenty of aspens close to the shore, ensuring a good supply of favorite food, harvested without a great deal of trouble. One would think that the inhabitants of this colony led a much easier life than that of most of the others.

The small abandoned pond found where the North Fork of Elk Creek enters the Elk Creek meadow is somewhat unique with its long, curving dam, extending around almost three quarters of a circle, though far from circular in outline. There must have been a considerable aspen grove here at one time, the inducement for the construction of this peculiar dam on almost level ground, and making but a small pond after all. When the aspens were used up the place was abandoned.

At Lava Creek the large roadside pond is formed, not by backing the water up the stream itself, as is commonly the case, but up a tributary side valley or depression. The stream enters the pond from one side at the lower end, turns sharply to the left, and a short distance below the bend the long dam was built, making a pond approximately a third of a mile long. The animals knew what they were doing when they located here. The subsidiary or tributary ponds above are either on the creek or to one side. A large lodge is in the roadside pond, and one in an upper pond.

The Lava Creek Side-Gulch Colony is perhaps an illustration of what the beaver will do when pressed by the scarcity of food. The steep, narrow gulch is

about as unfavorable a place for the construction of dams and ponds as one often finds, yet the animals had several of these, and were busy cutting the remaining aspens, which had to be dragged down over a rough, rocky hillside, and they were also feeding on Douglas firs. Springs must supply the water as there is no stream here.

In marked contrast to the preceding is Beaver Lake, where a dam more than 1000 feet long across a wide level valley once made a very large pond. This is now mostly a meadow. Nothing is known about the history of this place, but doubtless it is very old, and the work of successive colonies, the dam being gradually lengthened during the successive occupations.

While the beaver work in the Yellowstone Park presents a wide range in location and conditions, the subject is by no means exhausted. Elsewhere the animals encounter widely different problems. In Colorado I have found them in streams meandering through wide, level valleys, where a dam across the stream would make a large pond with deep water; and in the same stream have seen dams built but part way across, in such a manner as to check the flow and create deep, quiet water between the dams. Other streams have closely successive dams thrown clear across, often in groups of three or more, making a series of ponds, with lodges and also burrows in the banks.

While much beaver work seems to be accomplished in a haphazard, hit-or-miss fashion, I think that the animals can usually overcome any ordinary natural difficulties they may encounter and accomplish their objects in securing food, shelter and protection from enemies.

The Yellowstone beaver are living in a region very different from Michigan, where Morgan ('68) made his classic study of the beaver, and from Newfoundland, where Dugmore ('14) obtained much of the material for his book; yet they are adaptive enough to work out their problems successfully there, and no doubt this is the case wherever the animals are found. However, some sort of available food supply is the prime essential, and in the case of the Yellowstone beaver this now appears to be a matter for concern, as discussed later (pp. 183–184).

The Wanderings of the Beaver. Evidently the beaver are inveterate wanderers, exploring every river and creek to the very springs at its source, at least at the lower elevations. These waters are their natural trails, leading through open, treeless meadows, as at Yanceys, or the densest coniferous forest, as along Tower and Carnelian Creeks (Figs. 33, 79, 94). Signs of them are also to be found on the shores of ponds far removed from streams or sheltering woods. The occasional repairing of dams in old works along formerly inhabited streams, may be accounted for by this temporary use as homes or highways on the part of roving beaver. While rarely observed on these explorations, since they are chiefly nocturnal in habits, the numerous indications along the waterways are unmistakable. Mr. M. P. Skinner also informs me that the Yellowstone beaver wander widely in summer, and are sometimes found at considerable distances from water.

Although I failed to see any beaver far away from their works, a man whom I met near the Yellowstone Bridge colony one afternoon told me that he had observed a beaver climbing high up on the bare north hillside shortly before I came along, and that it had not come down again. I remained there for a considerable time, but though I kept a close watch on the hill, I saw nothing of the animal.

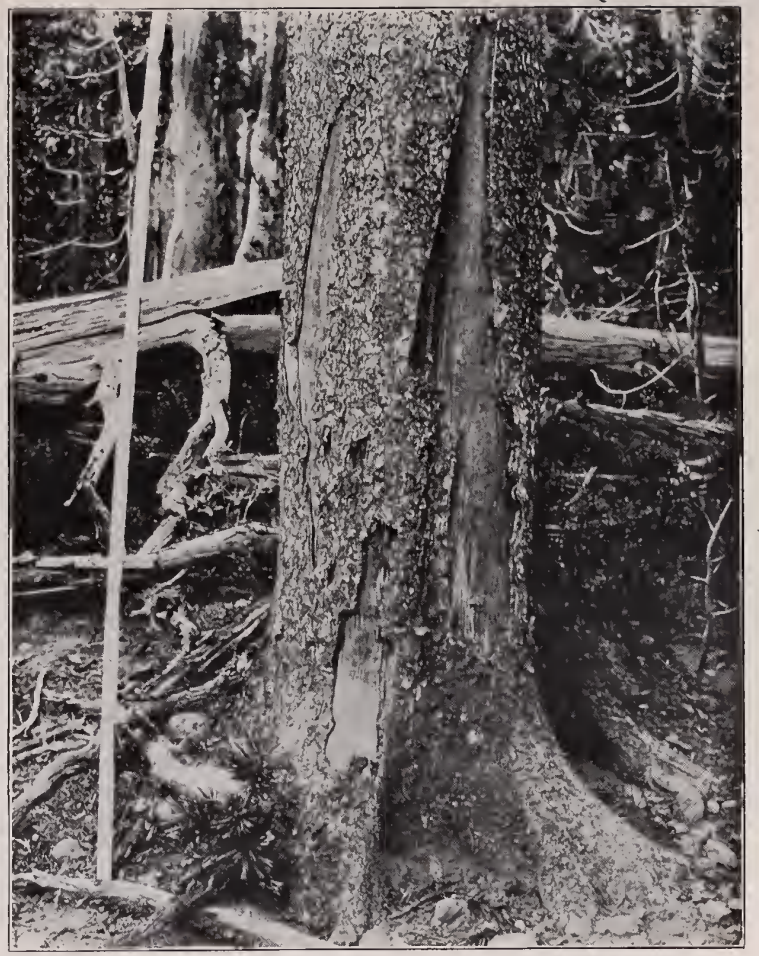

Fig. 110 (6164). A lodgepole pine near Lewis River with the bark torn off in triangular strips by the beaver. Aug. 29, 1923.

Fig. 111 (6167). A lodgepole pine 14 inches in diameter, with the bark and wood gnawed at 6 feet above ground. Aug. 29, 1923.

Fig. 112 (6171). A 6-inch lodgepole pine stump with remarkable spiral notch. Stump 5 feet 9 inches tall; lower notch 42 inches above ground, spiral at 51 inches, upper edge at 63½ inches. Note ground cover of blueberry bushes. Aug. 29, 1923.

Fig. 113 (6169). Notched lodgepole pine trees and stumps near Lewis River. On 11-inch tree (right), notch begins at 50 inches up. Two stumps in center are both 6 feet high, 19 inches and 13 inches through. Spruces untouched. Ground cover of Labrador tea. Aug. 29, 1923.

The beaver while wandering up and down a turbulent river, like the Yellowstone or Lamar in the Yancey region, seem as thoroughly at home as on the sluggish brooks. Probably they have numerous burrows and hiding places under the banks for temporary quarters, but do not breed there. Evidently they have no difficulty in working their way up the tumbling rapids. Mr. Henry Lambert and a party with whom he was fishing, watched a beaver swim across the Yellowstone in the canyon about half a mile below Elk Creek, in 1921. The animal was working upstream and crossed the river several times. Whenever it came to rough water it dove and swam beneath the surface, coming up again in smooth water. It landed so close to a boy in the party that he laid a fishing rod over its back. In the summer of 1923 Mr. E. J. Sawyer and a party, while fishing by the Yellowstone Bridge near the mouth of the small creek, observed a beaver close by in the river. "It *stood* in the swift water close to the fishermen but apparently was afraid to pass them and expose itself in the shallower inlet where it would have been at a disadvantage. On the other hand it showed no inclination to attempt retreating into the swift current of the river. Finally the beaver worked its way along the edge of the river, keeping inshore from the main current, until it disappeared in another narrow but deeper inlet. Evidently it had entered a bank burrow under the water of this tributary."

Signs of beaver were noted at many points along the Yellowstone River in 1923. In the canyon above the Calcite Springs there is a little grassy flat where the shore is bordered with Douglas firs, cedars and alders, and here the beaver had been cutting and eating the bark from some of the alders and firs (see also p. 172). This is just below the point where the canyon abruptly narrows and is hemmed in by vertical cliffs on either side. Thence for a quarter of a mile up along the so-called "palisades" and "needles" there are continuous rapids, as far as the slack water above the mouth of Tower Creek. Yet the beaver certainly traversed them, notwithstanding the few possible landing places, and during late August felled two or three of the scattered Douglas fir trees clinging to the precipitous east slope (Fig. 96). From time to time we watched the progress of this cutting from the road along the rim of the canyon 600 or 800 feet vertically above.

Upstream, above the old Indian ford at the head of these rapids the river gorge opens out, and here on the low west bank were found abundant old cuttings,— giant cottonwoods at the water's edge and Engelmann spruce on the swampy flat behind.

Cliffs and falls, however, are effectual barriers, and how the beavers circumvent these and reach the headwaters is an interesting question. Tower Fall and Lost Creek Fall are notable examples of high barrier falls in box canyons, above which are located large beaver colonies. To pass these falls the beavers must make long detours. It seems probable that they reach Upper Lost Creek by way of the South Fork of Elk Creek and Lost Lake, necessitating traversing half a mile of dry woods and high grassland; or by climbing the steep wooded slope and around the box canyon. The Tower Creek works possibly are reached from the river by way of lower Antelope Creek and across the ridge near the public camp grounds.

In traveling across country the beaver are obviously open to attack from their natural enemies, but in the two summers' observations only one case was

noted of an apparent killing by a predatory animal. That the beaver sometimes meet with a fatal accident in their wanderings is shown by the following example. One day in July, 1921, when Mr. A. G. Whitney and a party of boys from his "Forest and Trail Camp" were exploring the cliffs at Lost Creek Fall, they discovered a beaver skeleton among the boulders at the top of the talus slope near the fall. It was in a deep hole, close under the vertical cliff, fifteen or twenty feet to the east of the fall (Fig. 11). By means of string and improvised hooks the bones were pulled up, and they proved to be the skull of a beaver with several vertebrae attached. I visited the place on September 2 and found the hole to be about seven feet deep; a narrow and somewhat crooked crevice between the vertical blocks of rhyolite which had fallen from the cliff above. I could not find any more of the bones.

Presumably this beaver was following up Lost Creek and had climbed this high talus slope in his efforts to find a way around the fall and cliffs, and presently fell into the hole from which it was impossible to escape, and perished there from starvation. That beavers frequently ascend the creek to the fall and turn back to search out another route to the headwaters is suggested by the fact that Mr. Whitney noted several freshly cut aspens on the bank halfway between Tower Fall Ranger Station and Camp Roosevelt in 1922.

It is significant that recently the beavers have been revisiting the various natural ponds in the Yancey region and are now engaged in clearing out the last groves and scattered mature aspens long their shores. Where they have found enough food for a colony, they have established a home, as on the pond northeast of Crescent Hill; but if there are only a few large aspens available they are felling the last of these in their apparently aimless wanderings, as in the case of the Twin Pond nearest the Lamar River.

THE ENGINEERING WORK OF THE BEAVER

Dams and Ponds. Beavers use four different types of construction: dams, lodges, burrows and canals; but not every beaver uses them all, many living only in burrows, and probably they are as well or better off for that. This happens when they are living on a stream too deep or swift for dams or lodges.

A dam is begun by laying twigs or branches on the bottom, butt ends upstream, and very likely forced into the bottom. These are covered with gravel or mud dug from the upstream side, stones also often being used. More twigs are then laid on top and covered, and thus the dam is built up until its top appears above the surface and a pond begins to form. The dam is carried up to the required height and the top is plastered with mud. The builders keep close watch on it, and are continually making repairs and additions. A beaver dam is never finished while the pond is occupied, its owners continually adding something to it. Perhaps the water may flow around the end. That is stopped with mud or sticks, whereupon the water in the pond rises so that the main dam has to be added to in order to hold this, and then more water goes out around the ends, and the process is repeated. I have little doubt that the long, crooked dams which we see were thus built, not by design, but by the continual effort to prevent the leaking over and around the dams. (See Figs. 60, 80, 97.)

As may be inferred from the descriptions of the various colonies in the Yancey Region, not all dams are built in streams. Some are built in gulches or on the sides of a valley to control the water from springs. The large pond in the Crescent Hill pond series, 340 by 800 feet, is controlled by a comparatively short dam, 165 feet long. The water is supplied by springs. In constructing this dam the builders selected the most suitable site, where the rather wide valley narrows somewhat, making it possible for this short dam to back up so much water. The Tower Creek works afford an example of a short dam controlling the water from a large spring and thus supplying an extensive series of ponds.

Let us return to the building of the dam. On the lower face are placed many sticks, often those from which the bark has been eaten, or willow branches are used, and I have seen good sized logs utilized, whose ends projected high above the dam. Whatever the material, these sticks are generally placed up and down the face, not transversely. There is invariably, I think, a trail over the dam where the beavers cross, and this is always where the stream is, so that they may go down into the water from above.

It seems to me likely that in beginning a dam some of the branches are customarily laid across the current, for I have seen a number of dams which appeared to be thus underpinned. Moreover, when a dam is cut through, whether by man or by natural agencies, there are always the ends of sticks showing in the cross section thus exposed, indicating they were deliberately laid crosswise.

Dams are not always built completely across the stream. I recall a series of three dams in Colorado, none of which extended all the way across the river. One of these was on one side, the other two on the other, and they were placed in such a manner as to deflect the water first to one side, then back again, forming deep, quiet pools. The diversion dam on Carnelian Creek already described (p. 118), also illustrates this method of building.

As to the length of dams, they vary from a foot or two up to several hundred feet in length. In the Yancey Region the longest was that on the North Fork of Elk Creek, 350 feet. That at Beaver Lake was 1,054 feet in length. Enos Mills mentions one near Three Forks, Montana, 2,140 feet long, more than one half of which was less than 6 feet high, two short sections being 23 feet wide at the base, 5 at the top and 14 high. Dams vary in height as in length, but I think are rarely more than 6 feet high on the lower face, usually less. The thickness of the base varies firstly with the height, and secondly with the age of the dam, for as the material settles with age it tends to spread; and silt also settles at the base, so that even if the structure does not increase in height it may become wider.

If a dam is abandoned it gradually goes to ruin, yet many of the dams in Yellowstone Park and elsewhere have probably been abandoned at times for a number of years, and then repaired and reoccupied by a new colony of beavers.

Lodges and Burrows. Lodges may be divided into two sorts, those built out in the water away from the shore, and bank lodges. The former must have a foundation of some sort to start with, as a small island, or an elevation of the bottom of the pond sufficient for a beginning. Seemingly the lodge begins with a burrow, covered with mud and sod, on which sticks are laid, much as in building a dam. The interior is kept hollowed out as the work progresses, and the

structure is more loosely built above the chamber to permit of ventilation. The floor is a few inches above water level, and is furnished with a bed of grass or shredded wood fiber. Dugmore says there are two levels to the floor, the lower for drying and feeding, the upper for a bed. There are usually at least two entrances to a house. In size they range from 6 feet in diameter up. The big lodge on Tower Creek, 33.5 by 39 feet, is the largest of which I have any record (see Fig. 82). Dugmore mentions one in Newfoundland nearly as large. An old house in a drained pond in Colorado, which I opened for examination, was 8 feet wide across the section, and 10 feet the other way. The chamber was 2 feet wide and extended back 4.5 feet. It was a foot high, but I suspect the roof had settled. It was furnished with a bed of swamp grass. Detailed descriptions of other lodges will be found above in the accounts of Upper Lost Creek and Petrified Tree Road Colonies (see pp. 44, 69).

Bank lodges are of two kinds, probably with intermediate stages between them. One sort is built against the bank, or with at least part of the structure projecting into the water, really a burrow extended and roofed over. The other kind is wholly within the bank, connected with the water by a burrow, and is simply a burrow enlarged and covered. A new and an old one of this latter type were seen on Carnelian Creek (Fig. 93). The former was four feet back from the stream bank, 15 inches above ground level, and 3 feet in diameter. The lodge in pond No. 14 of the Yellowstone River Bridge Colony is an example of the first kind (see Fig. 7), and that in Pond No. 7 may possibly belong here.

Mention has been made of the mouths of burrows exposed on the east side of Pond No. 3 on the North Fork of Elk Creek. There were several of these burrows (Fig. 64). An attempt was made to excavate two of them, but without much success. The slope of the hill is quite steep there, which renders work of this sort difficult. The first hole ran but a few feet into the bank and then made a turn back to the pond. Perhaps it was merely a place of refuge. In opening the second burrow we dug down to it from the surface at some distance beyond the entrance, and found it to be 3.6 feet under ground, at too great a depth to follow by digging, considering the limited time at our disposal. A place was found higher up on the hill where the surface had caved in, and the burrow evidently continued from our excavation to this point, which was the end. The total length of the burrow was 31 feet. It was 1.4 feet high and 1.7 feet wide. There was no enlarged cavity or nest at the end of the hole. I am inclined to think that this was an unusually long burrow. A combination of canal and extensive burrows at the Elk Creek Bench Colony has been described (p. 73).

Canals. I am somewhat disposed to the belief that in some respects the canal is a higher engineering achievement than the dam. To deliberately plan and dig a channel in which to float logs to a pond, and not only that, but also to build dams in this channel to hold the water to a desired level, is an intelligent act. This is what the animals do, however, when the trees are at a distance from the shore, and the ground is flat enough to permit of carrying water in on a level, or controlling it by miniature dams. These ditches vary in width from one to four feet, in depth from 8 inches to 2 feet, and the length may be but a few feet or very much more. Morgan mentions two in Michigan 523 and 579 feet long respectively. Those on Tower Creek were 90 and 150 feet long respectively.

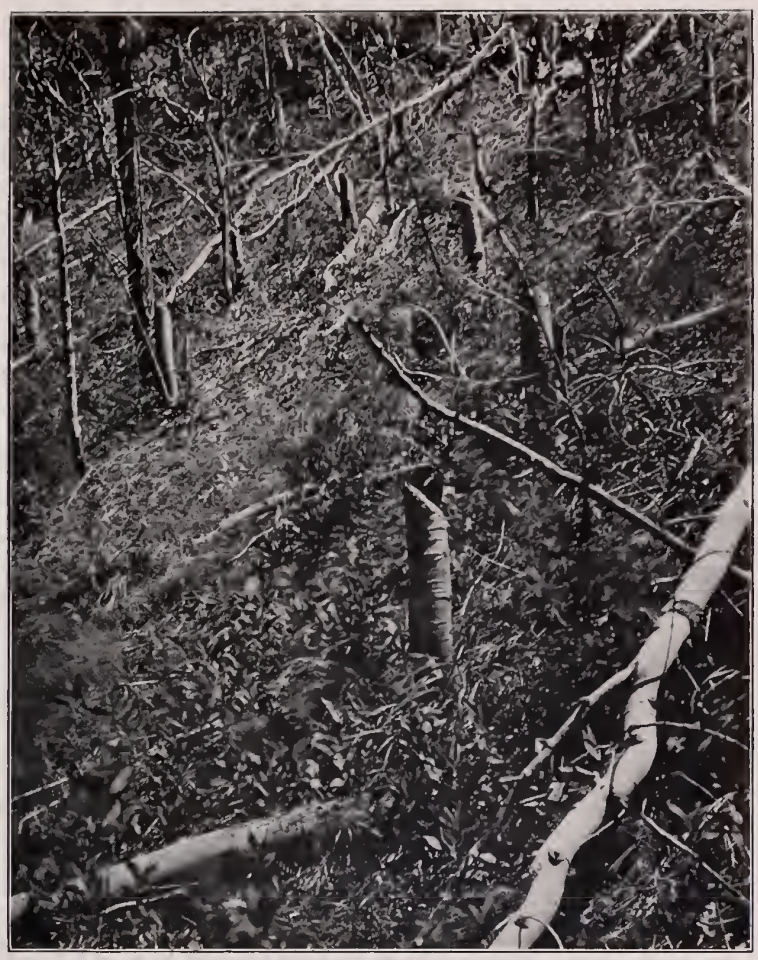

Fig. 114 (5037). Aspen stumps cut on upper side, on steep east slope above Pond No. 14, Upper Lost Creek. July 16, 1921.

Fig. 115 (5127). Aspens cut almost through on upper side and all felled down hill. Steep slope above Tower Creek works. Aug. 8, 1921.

Fig. 116 (5283). Aspen stumps on steep slope near Tower Creek, cut nearly through from lower side, but actually felled by a higher cut from upper side. Sept. 6, 1921.

Fig. 117 (5147a). An aspen about 10 inches in diameter, cut evenly all round and breaking off at center. On flat at North Fork of Elk Creek. Aug. 10, 1921.

Berry ('23) has described one in Montana whose total length, including a slough which was utilized, was 745 feet. Where the slope of the ground is such that the water would not maintain its level in the canal, a small dam is built to hold it back. Such a two-level canal is described above in the account of the Tower Creek works.

The skill of the beaver in excavating ponds and canals is exhibited in a number of interesting ways. If the operations are begun on a flat the dam is commonly largely composed of mud and sod dug from the pond formed behind it, the pond being deepened and the dam raised at the same time. If the pond is shallow, channels or runways are cut along its bottom and tunneled under the lodge, as shown in Figs. 18 and 50. In excavating a canal the soil may be thrown up on the bank directly, as in Fig. 87; or if needed for a dam it may be removed entirely and transported a considerable distance. An illustration of this latter was the canal on the southern edge of the works above the Yancey cabins, on the South Fork of Elk Creek. Here the channel was cut back straight and one foot wide into the up-sloping marsh above the uppermost pond. It was dug as clean and parallel-sided as though trenched with a spade, and carried back on a level until nearly two feet deep, whereupon excavation stopped and a trail led from the end out onto the turf. But there was no sign of the excavated material anywhere, except in the dam below, which was composed largely of black mud.

The Draining of Old Ponds. A number of ponds which had apparently been deliberately drained by the beaver attracted my attention this second season (1923) and I indulged in some speculation as to the causes.

Perhaps the most prominent example of this work was Pond No. 12 on Lost Creek, which I found drained on my first visit, July 14. An opening had been made through the dam at the bottom of the stream channel, so that the draining was thoroughly done, and the only water remaining was the stream flowing in the channel from the pond above to that below.

The beavers were evidently abandoning this pond because the adjacent supply of aspen was now exhausted. But why did they go to the trouble of draining it? A plausible reason appears to be that they did not like the water to stand in the pond and become stagnant, and thence pass on to a pond below which they were using. By emptying the pond and permitting the stream to run through unchecked a more desirable water supply was obtained, aerated and cooler. Or, the pond no longer being of any direct use, it may have been neglected, and a chance leak was perhaps enlarged as a short cut to the pond below.

The case of Ponds Nos. 4 and 5 on the North Fork of Elk Creek seems somewhat different. These were full of water on July 25 and empty the afternoon of July 28, 1923, drained by means of a hole through Dam No. 5. One would expect the beaver would have wished to keep them full for a waterway to the upper ponds on Elk Creek, and they were not so large that by themselves they would constitute very much stagnant water. As there is a series of ponds above them, one or two being of considerable size, it may be that the water after passing through all of these, needed aeration, and so these two ponds above No. 2, into which they emptied, were drained for this purpose.

It may be attributing unusual intelligence to the beaver to assume its reasoning the matter out in this way; but what do we really know, after all, about the workings of an animal's mind? Or do the beavers tunnel or cut the dams *instinc-*

tively when the pond water becomes foul, or from some other necessity? In some cases where we are inclined to reason out the beavers' problems it well may be that instinct sufficed for them.

It was a different situation at Pond No. 1 in the Elk Creek Bench colony, evidently formed in 1920. The water in this pond began to fall in midsummer, 1921, and not much was left by September 4; and in 1923 it was empty and largely covered with grass. This was not a case of draining out the water, but rather, cutting off the supply, held back in the ponds above. There is never a large supply here, and very little escapes from the larger of the ponds above, where the beaver now live.

The draining of the roadside pond on Lava Creek in May, 1923, when the dam was torn out for a space of 15 feet, may safely be regarded as the work of some man, for reasons not yet clear. The low dam at the outlet of Lost Lake likewise had been torn out in the spring of 1923. This was said to have been done by the field men of the Public Health Bureau as a part of their mosquito control work. The lake was lowered little, if any, and the beaver did not repair the dam during the summer.

Enos Mills expressed the opinion that beavers sometimes drained their ponds and allowed them to stay empty for a time for sanitary reasons, in order to permit the sun and air to purify them. I know of one instance where a pond was full in February, empty at the time of my next visit the following October, and refilled a month later.

Cutting and Transporting Trees. The habits of the beaver in cutting trees were given considerable study in the Yancey region, especially in 1921, when the following notes were made. In the descriptions of some of the colonies this subject has already been dealt with because of its special bearing upon the occupancy of those colonies, but there are certain points which may best be treated separately.

One of the questions to which especial attention was given was the direction in which trees were felled, with reference to the slope of the land, and to the side upon which the deepest cut was made. All reliable observers and writers on the beaver are agreed that the animal does not deliberately cut trees so that they fall in any desired direction. The direction of the fall is determined by various factors. The idea still crops out in popular articles that a beaver can make a tree fall wherever it wishes. To obtain further evidence bearing on such statements it seemed desirable to make careful notes on this subject. I was long ago convinced of the error of the popular view, but my recent experience in the Yellowstone afforded a more favorable opportunity to make observations on this point.

A woodchopper, in felling a tree, makes the deepest cut on the side toward which he wishes the tree to fall. If we try to apply any such rule to the stumps and fallen trunks in our examination of beaver cuttngs, we soon see that it does not hold. In the first place, where the trees are small, say three inches through or less, they are seldom cut from more than one side, and the direction of the fall is determined by the leaning of the tree, the one-sidedness of the crown, or possibly the direction of the wind. At the Tower Creek works, above the large pond, much cutting was being done in 1921 among the aspens growing on the steep hillside. Of the trees which had been cut, and whose trunks still remained, nearly every one had fallen down hill, without regard to the side from which the cut was

Fig. 118 (5064). An aspen 4.6 feet in circumference deeply cut from one side. Before finally felled it was cut clear around. The kerf is narrow and clean cut. July 22, 1921.

Fig. 119 (5275). The large aspen shown in Fig. 118, felled between Aug. 28 and Sept. 4, the date of this photograph. This tree stood among scattered aspens, pines and spruce, on the flat at upper North Fork of Elk Creek.

Fig. 120 (5141). Freshly cut aspen logs, near Elk Creek Bench colony. The ground is flat, and the trees are cut evenly all around. Aug. 10, 1921.

Fig. 121 (5261). Chips from beaver cuttings: a, a, aspen; b, b, alder; c, c, lodgepole pine. Six-inch rule at left. Sept. 3, 1921.

made. Very few had been cut from more than one side. An examination and count was made of the stumps to determine on which side the cut was usually made. Of 61 stumps, 26 (43 per cent) were cut on the uphill side; 22 (36 per cent) laterally; and only 13 (21 per cent) from the lower side. The explanation for this is simple enough; it is much more convenient for a beaver to cut from the upper side, when working on a slope. Some particular cases were noted. One tree with the cut on the upper side fell uphill, while another close by, cut on the lower side, fell down hill, and near it was one cut on the upper side which fell down hill. Probably the tops were heavier on one side or the other. There were five trees close together, all of which fell down hill, though all were cut from the upper side (Fig. 115). These aspens were from three to five inches in diameter.

Farther down on Tower Creek I found a couple of stumps close together on a rather steep bank. These stumps were 24 to 30 inches high and 6 inches in diameter. Each had been cut nearly through from the lower side, and then this cut had been abandoned and the beaver had gone above, made a new cut from the uphill side several inches higher, and it was by these last cuts that the trees had been felled (Fig. 116). Perhaps the lower cuts were abandoned because of the danger of the trees falling on the beaver; or they may represent winter work, during different levels of snow.

The same general habits hold for all moderate to steep slopes. In his letter to the author relative to the aspen cutting near the Yellowstone River Bridge, Mr. M. P. Skinner says: "I concur in your statement that on a steep hillside in the great majority of cases the cut will be made on the uphill side, or to one side or the other, rarely on the downhill side; and all the cutting will be done from one side, as in these trees. Of a group of three aspens two were cut on the uphill side; one cut on the downhill side had fallen uphill and lodged in another tree."

Near the large pond, No. 2, on the North Fork of Elk Creek, an aspen more than 12 inches in diameter was cut almost entirely through from one side, and not at all on the other, and fell toward the cut. Not far away was another about the same size which was cut in the same manner, which had fallen away from the cut. These trees were on a flat. Although on hillsides the beaver usually cut only from the upper side of the tree, it was noticed that where the ground was level, or nearly so, the animals cut quite evenly all around, so evenly that in many cases when the tree fell the center or heart of the tree was the uncut portion which broke (Figs. 117, 119, 120). In other words, no deep cut had been made from one side which might have influenced the direction of the fall; that had been entirely a matter of chance. It may safely be stated that a beaver cuts a tree in the manner most convenient according to the slope of the ground, and lets it fall where it will.

The height of the stump varies greatly, and this is so even on the same hillside (see table, p. 178). On the North Fork of Elk Creek 32 stumps were measured on ground which had a gentle slope. The tallest was 2.4 feet high; the remainder ranged from .7 to 1.5 feet in height. The stump measurements were in cases made from the ground to the lowest part of the notch. Not far away were two stumps each more than 12 inches in diameter, one of which was cut at one foot and the other at 1.2 feet above the ground. The large aspen, 4.6 feet in circumference, which stood for a long time partly cut, gave the following measurements: Lower edge of notch 1.2 feet above the ground; upper side of notch in wood 2 feet, and upper

edge in bark 2.3 feet above ground. Thus the animal was making a notch over a foot wide in this large tree. As mentioned in the description of the North Fork colony, this tree stood partly cut from July 20 to August 28, deeply chiseled into, from one side, and was felled between this last date and September 4 (Figs. 118, 119). At another place on the same stream stood an old stump 3.3 feet high, and about it, but not more than two feet distant, were four others, from .8 to 1.2 feet high.

On Lost Creek, stumps were measured on the steep hill slopes at both sides of the ponds, 75 being tallied on the east side, and 60 on the west. The height of the stumps varied from 4 to 24 inches, the great majority ranging between 12 and 20 inches. The aspens were usually from 3 to 5 inches through, the latter size being rather exceptional. One small stump, cut at 2½ inches above ground was also found.

It would appear that the surface of the ground determines, to some extent at least, the height at which a tree is cut, and that trees on slopes are cut higher above ground than those standing on the flats. Some, if not all, of the exceptionally high stumps were doubtless cut in deep snow. The tallest aspen stump found in 1921 was one of the group of stumps mentioned in the account of the North Fork of Elk Creek, and was 4.1 feet high. An alder stump on the same creek was considerably higher, but may have been cut under unusual conditions, perhaps while bent close to the ground. Stumps 4½ feet high were observed at the Tower Creek works in 1923. These were of trees 2 to 4 inches in diameter, situated at the top of the north slope where the game trail follows the rim of the bench. Evidently they were cut when the snow was deep. The tallest stumps were of lodgepole pine, up to 8 feet and 8 inches high, near Lewis River Fall (Figs. 106, 108). These have already been discussed (pp. 129–130).

When a beaver starts to fell a tree, making a cut above and another several inches below and jerking out the chip, the first chips are likely to be longest. But if the tree is large and is deeply cut from one side, the chips are correspondingly smaller and the kerf narrower,—as in Figs. 107, 118. The species of tree also determines somewhat the character and size of the chips because of the varying hardness of the wood.

Collections were made of the chips cut by beaver from three different species of trees,—aspen, alder and lodgepole pine (Fig. 121). Of these, the largest chips were cut from aspens, the maximum size being 7.5 inches long by 1.5 inches wide. Chips 5 to 6 inches long by one inch wide were not at all uncommon in this lot. The thickest chip noticed was half an inch thick. From the above size they range down to tiny fragments of wood. The appearance of these long chips indicates that the animal made one or more bites into each end of the piece and then tore out the chip with its teeth. Aspen chips seemed to be more splintered than those from the other kinds of trees.

The longest alder chip was 5 inches long by 1 inch wide; but those I collected averaged up in size very well, there being many from 3 to 4 inches long, and they were noticeably clean cut. I found but one alder from which I could get chips.

The lodgepole pine chips are decidedly smaller than those cut from either of the other species of trees. The largest is 1 by 4 inches; most of them are much

smaller and they are decidedly thinner. These chips came from the large pine cut by the deep spring on Tower Creek (Fig. 128). Their smaller size shows that it must have taken much more work to fell that tree than an aspen of similar size.

For transporting their food and construction materials the beavers make trails and slides, canals and runways over dams, and possibly also form additional ponds for water routes. The trails are especially marked where leading through marsh grass, or on hillsides where aspen poles and sticks are dragged down, the work being concentrated on the one or two best located trails (Figs. 10, 14, 65). On steep slopes these take on the character of well-worn slides, as in Fig. 81. Wherever feasible, canals are excavated out to the aspen groves, or as near as may be; and advantage is taken of any available spring rill or seepage for supplying such waterways. The mud for filling in the cribwork of the dams, or plastering the lodges, or for preliminary earth dams where there is no great pressure, is dug from the pond or the channels along its bottom, or brought from the canals in process of excavation.

In transporting a stick or pole, the beaver holds it with its teeth near the end and drags it thus diagonally down a slide or floats it alongside as it swims to the lodge or dam (see Fig. 127). Bushes and twigs are cut off one after another until the beaver has as large a bunch as it can easily carry, and this is dragged and towed similarly (Fig. 126), and frequently carried under water and into the lodge. Mud is transported in the fore paws and held close under the chin; and in carrying it up onto a lodge, the beaver either pushes it up the oozy incline, or walks upright over the sticks to the desired point.

It is important to know how far from its lodge the beaver will go to cut trees or secure food, under varying circumstances. I hoped to obtain some definite information on this point, but the data obtained were decidedly inconclusive, for in each case there were no live trees of the species being cut beyond the stumps farthest from the water. Thus at Crescent Hill there was an aspen stump 220 feet distant from the shore, but there had been no accessible aspen trees growing farther away. At Lost Creek, on the hillside to the east of Pond No. 12, the stump farthest from the water was 138 feet away, and on the west side the farthest was 173 feet distant. In each case the measurement was taken on a very steep slope, and also in each case only lodgepole pines grew immediately above these highest cuttings, and thus there was no reason for the animals going farther.

On Tower Creek, at the deep spring colony, aspens had been cut 130 feet from the end of the canal, and the length of the latter added to this would make about 220 feet, but the shortest distance from the most distant cuttings to the pond would doubtless be somewhat less, very likely not more than 200 feet.

At none of the other places visited had the beaver gone to any such distances to cut trees for there was plenty of available material nearer. This is a subject, however, on which observations should be made wherever possible. Protection from predatory animals and man bears directly on this problem.

NOTES ON HABITS AND BEHAVIOR OF THE BEAVERS

Observations at Colony near Yellowstone River Bridge, 1921. The ponds near the Yellowstone Bridge, less than a mile from Camp Roosevelt and Tower Fall Ranger Station, afforded an excellent opportunity to watch the beaver and study their habits. These works are so near the Camp that it was a delight to guests to walk there after supper and pass an interesting hour or two observing the creatures before darkness shut down. I spent a number of evenings in this manner and regret that the fatigue of daily field work prevented me from going more often.

After four in the afternoon the beaver were to be seen in their ponds swimming about, playing, going ashore for food, returning with it and eating it, or diving and carrying it into the lodge; in short, pursuing all their accustomed activities. This was done quite unmindful of the spectators, who, often to the number of twenty-five or thirty, stood silently at the roadside looking down upon the ponds and watching the animals, which were also nearly oblivious to the noise of the automobiles which frequently passed. Such an unusual opportunity is of course the result of complete protection. Many of my observations were made at Pond No. 7, where the lodge was located (Fig. 6), and the notes made there cover the usual behavior as observed at the various stations.

If one chanced to be near by when the beaver first came out in the early evening, probably the preliminary activity would be to swim about the pond for a minute or so, perhaps in indecision as to what it would do, or more likely reconnoitering to see if everything was all right before going about its business. Sometimes two or more beaver would thus be seen at once. After these first observations, the beaver would usually do either one of two things: pull out and scramble up the hillside on the opposite side of the pond, or else go over the dam to one of the ponds below. If the former, it would cut a bunch of rose bushes or seedling aspens, as many as it could hold in its mouth, and bring them down to the pond, dive and take them into the lodge. Sometimes it ate a little while on shore, but never very much. Evidently it did not feel safe there, out of water, the beaver's protecting element. If it went down over the dam it usually gathered food somewhere below, either on the hill slope, as when going directly up out of the pond, or beside the stream. Here, grass was often cut and taken to the lodge. It is a question whether this grass was used as food, or whether it may have been taken into the lodge for bedding.

At night, when nobody was about, large aspens were being cut on the hillside above the road, and branches and sections of the trunks were taken to the pond, and the bark was eaten there. One stick 10 feet long was cut off and rolled or dragged below the road to the waterside and entirely denuded of its bark.

Living in the lodge in Pond No. 7 were a pair of adult beavers and three yearlings, and, as was ascertained later, at least three of that spring's young. These last, however, did not appear in public until about August 22.

Usually in the evening there were two or more beavers swimming and playing in this pond; and I sometimes saw the three yearlings playing together. A good deal of this play consisted of trying to push each other about; and once they pushed so vigorously that both rolled completely over in the water, belly up. I watched closely when the animals were thus playing, but could not see that they

Fig. 122 (6044). Daylight photo of a beaver feeding in a pond on North Fork of Elk Creek. July 28, 1923.

Fig. 123 (6060). Daylight photo of a beaver in a pool above Dam No. 3, North Fork of Elk Creek. Aug. 1, 1923.

Fig. 124 (6054). Two beavers swimming in Pond No. 2, North Fork of Elk Creek. July 28, 1923.

Fig. 125 (6055). A beaver swimming in Pond No. 2, North Fork of Elk Creek. On first coming out toward evening the beavers usually swim about the ponds several times as though reconnoitering. July 31, 1923.

were holding each other by their teeth. My assistant, Mr. E. L. Spackman, Jr., said that while playing they made a noise something like the mewing of a kitten, but sharper.

Frequently, instead of proceeding downstream over the dam, the animals made their way into some of the upper ponds and carried on their activities there, going ashore after food, or playing about in the water. One afternoon I visited the ponds between three and four o'clock, and at about four a beaver proceeded upstream. It went ashore and cut some willow twigs, brought them down into the water and began eating them. It had selected a place under some dead aspens which had fallen down over the water, with others lying about on the shore. I was very anxious to secure a picture of this animal, and had much difficulty in getting out on the fallen trees to a place where I could command a clear view of the proceedings. My maneuvering disturbed the beaver and it disappeared. Presently I discovered it floating noiselessly in the water just below the dam at my left, and watching me. There was a small pile of sticks and débris there under which it could hide. Possibly they protected the entrance to a burrow. Then the animal disappeared again, and before I quite realized it had gone, it was back at the other place eating its willows. To get there it had to pass under water almost directly beneath where I stood on the logs, but I neither saw it come nor go, although the performance was repeated several times.

The noise of a focal plane camera shutter did not seem to disturb this beaver, but unfortunately, the poor light prevented the getting of pictures that day. On the following afternoon when the same or another beaver was swimming in the pond directly below where I stood upon the road, the whirr of the shutter caused it to dive with a resounding slap of its tail and a great splashing of the water. One curious fact was that while the noise of the shutter usually did not alarm the animal, the sound made in tearing off the paper tab of a film pack would often do so. This beaver was noticed on several occasions feeding secluded under protecting sticks. One evening Dr. Charles C. Adams and I saw it there eating the bark from a fair sized aspen stick, and one could distinctly hear the noise made by its teeth as it bit off the bark. It is presumed that the same individual was seen on each occasion.

The next to the lowest pond, No. 2, appeared to be the home of three or four beaver; there were at least an adult and two yearlings, for I saw that number in the water there at one time. Their activities were similar to those of their neighbors above. There was no lodge here, but a couple of small piles of sticks against the bank opposite the road evidently protected the entrances of burrows. The animals were seen to come from under these sticks, their appearance being signalled by the disturbance of the water as the occupants swam out beneath the surface. One afternoon as I stood on a rock which projected into the pond, one of the yearlings lay quietly floating close to me, giving an excellent opportuity of estimating its length, which I did not think to be more than 30 inches, and probably two or three inches less. Similarly, in the other pond, I one day had the chance to judge the length of one of that spring's young, and thought it did not exceed 18 inches. Its body seemed to be about the size of a rather large muskrat.

One evening, at the lower pond, a beaver was on shore cutting and eating small choke cherry bushes, while half a dozen of us stood less than ten feet away

and watched. Another afternoon, a little before six o'clock, as we rode past in a heavy truck, rumbling up the grade in low gear, a beaver in the water making its supper off of aspen bark apparently did not give us even a passing glance. I mention these particular instances to show how indifferent these animals had become to human beings.

I noted a rather curious incident one evening. While I was watching at Pond No. 2 a beaver swam to the opposite shore, above the upper burrow, and came partly out on land, when suddenly a woodchuck made its appearance in the grass just above the water, apparently somewhat frightened. The beaver evidently considered the woodchuck harmless, for it merely turned away leisurely and dove into its hole, while the woodchuck continued feeding. I suppose the beaver had noticed that there was something on the shore and went to investigate, but finding nothing unusual, immediately lost interest.

One beaver which I frightened with the camera shutter, as I stood working on the bank above, and where it was in water too shallow to dive or swim, fairly loped over the logs lying in the shallows until it reached deeper water where it could sink out of sight.

While I did not have any such good fortune myself, a man connected with a moving picture company happening along the road one afternoon secured pictures of a beaver working at a tree.

Mr. A. G. Whitney reports seeing, in 1922, a beaver cutting a 4-inch dead aspen on the opposite side of one of these ponds. A party walking down to the river bridge toward evening watched the beaver for a few minutes. When they returned at dusk, the tree had been felled.

Where not disturbed, beaver seem likely to come out at any time of day. I saw one at Lost Lake at 10 a. m., and one near Crescent Hill at noon. I have described my experience with this latter animal in my account of the Crescent Hill colony.

With 8 beavers ascertained to be living in Pond No. 7, and 3 in No. 2, the population of the Yellowstone Bridge colony in 1921 numbered at least 11 individuals, old and young. But in 1922 the colony was abandoned. The attention of tourists interested in beaver was then directed to the small colony on the South Fork of Elk Creek at Yanceys, and the Elk Creek Bench colony; and in 1923, to the flourishing colony on the North Fork of Elk Creek. In 1924, as the beaver activities had slackened at all these colonies, tourist interest was transferred to the colony active near the Petrified Tree on upper South Fork of Elk Creek.

Observations on Beavers at North Fork of Elk Creek, 1923. The following pages contain observations made on the habits and work of the beaver on the North Fork of Elk Creek, but not mentioned in the preceding accounts of any of the colonies. I have thought it best to give these notes just as they were set down soon after my different visits to this place, usually the same evening.

On the afternoon of July 28 I went to the North Fork of Elk Creek to watch the beaver there, as I had heard many reports of the animals being seen in the large pond (No. 2). Three ladies, guests at Camp Roosevelt, accompanied me, besides Mr. Mills, my assistant.

We reached the ponds quite early in the afternoon, but there were some photographs which I wished to take, and a few stations to revisit, so that my

time was taken up with this work for a while. About three o'clock I walked along the ridge east of the ponds until above Nos. 13 to 15. Here I found that the beaver had been doing considerable cutting. One aspen evidently had been felled only the night before. The trails down the hill into Pond No. 15 were well worn and undoubtedly much used.

I watched the pond a little while and finally saw a beaver. I returned to the rest of the party and two of the ladies came back with me. A single beaver came out about four o'clock and swam up the pond and disappeared, and did not come back. We saw two or three muskrats, one of which was carrying grass in its mouth.

About five o'clock we returned to the large pond and found that the beavers there had come out and were quite active. From that time on until after eight, when we left, one or more beaver could be seen swimming about, and they were still in sight as we took our departure. Much of their activity consisted in swimming around the pond in an aimless sort of way, occasionally diving and soon reappearing. They did not seem to play much; I saw this but once. Eleven beavers were counted in all. Some were adults and some were yearlings, how many of each I cannot say.

The animals frequently came through the passage under Dam No. 3 into the little pool of water just above, and lay there quietly, and also sometimes swam up the little channel above. Mr. Mills said he saw one of them eat some of the green alga which was in the pool. He noted this two or three times. He said that after the alga was eaten the beaver nibbled or bit on a small stick which was near by.

Dam No. 3 seemed to be undermined or to have a passage westerly from the tunnel, for the animals often entered the tunnel and came out into the pond farther along the dam. This dam was an excellent place from which to watch them, for the beavers came close to it and paid very little attention to the people there, and one could move along its length anywhere to make observations. We ate the lunch we had brought while sitting on the dam watching the beaver, without disturbing them. The lodge toward the westerly end of this dam appeared to be occupied.

Another place where the beaver frequently came was west of Dam No. 3. They dove under a fallen tree, came up in a little channel, and swam along this into another, remaining there a short time, and then came out, returning by the same route. What they did there we could not make out, but it seemed a regular procedure, not only on this day but at the other times I was there.

Often the animals swam to the westerly end of the pond, and brought back from there green stuff with which they went into the lodge. Others sometimes went over Dam No. 2 at the trail, and returned with green willows. From the west end, besides willows, I saw one lot of small aspen twigs and one of rose bushes. With one exception all this was taken into the lodge. The exception, a load brought just as we were leaving, was carried into a burrow in the hillside near the east end of the dam. I thought there must be a family of young in the house which had not yet come out, and this food was taken in for their benefit.

I took a number of pictures, making repeated exposures as long as the light was good, and the noise of the graflex shutter did not appear to frighten the

animals at all. Occasionally one would be sufficiently disturbed from some other cause to dive with a slap of its tail, but almost always they dove or sank quietly, even when a small stick was thrown into the water near them.

I went to the same place the afternoon of July 31, arriving there about 3:30. I set a camera on a tripod on Dam No. 2, focused on the trail where the beaver crossed to go below, with a thread across the trail, and then returned to Dam No. 3 to watch. While waiting we made some examination of the dam and found there were several openings to either side, and connecting passages underneath in the body of the dam, as shown in Fig. 59.

It was 4:50 p. m. when the first beaver appeared, and it came out into Pond No. 2, not from the lodge, but from the dam almost under where we were sitting. I noticed the commotion in the water before the animal made its appearance. It swam near the dam a moment, and then went up to the farther end of the pond, swam about there for some time, then returned and went through Dam No. 3 into the pool above, where it sat in the water and ate some algae. It seemingly gathered it with its paws and conveyed it with them to its mouth. It then went up the canal or ditch to the small ponds below and northwest of No. 13.

The first beaver came out of the lodge about 5:10 p. m., and soon several were out. One came through the dam and started up the ditch but was frightened back.

A beaver swam toward the trail where the camera was set, and coming near the latter was apparently frightened by it, and dived with a great smack of its tail. It and another swam around there for a long time, evidently wishing to cross the dam but afraid to do so. Later I went around to get the camera, and while there an adult beaver came on the dam farther east, ate grass on the top, went down the lower side, ate willows, and finally returned to the pond, but without bringing any willows back with it, though I expected it would do so.

The animals did not begin bringing green food to the lodge until 6:30 p. m. or later. Both willows and aspens were brought. One beaver brought a bunch of aspen twigs (Fig. 126) and took it under the dam, entering the hole where the first came out. My companions leaned down near a hole in the top of the dam and could hear the young beavers in there. Presently the parent came out with its fur a good deal mussed up and an aspen leaf on its back, and swam around for some time. It was evident there were two families in the pond, one living in the lodge, the other in the dam.

We saw a beaver swim across the pond with a short log, evidently from Dam No. 3, as it was an old piece. It carried this to the break in the other dam, onto that, and placed it down on the face. In transporting it, the log was floating on the left side of the beaver, which held it with its teeth a few inches back from the forward end.

Though the beaver's ears are not large they are certainly prominent when the animal is swimming, as they are carried erect and are clearly defined against the head.

I took especial pains to note the manner of swimming. The chief mode of propulsion was of course by means of the hind feet. The tail was usually carried motionless behind. Once or twice I saw it apparently used with a sculling motion. The animal kept on straight ahead, so was not steering with it, though I did see them steer with the tail at other times. Also I sometimes saw the animals turn

Fig. 126 (6053). A beaver carrying aspen twigs, with the leaves on, to the lodge in Pond No. 2, North Fork of Elk Creek. July 28, 1923.

Fig. 127 (6061). A beaver towing an aspen stick, near the dam in Pond No. 2, North Fork of Elk Creek. Aug. 1, 1923.

without using the tail as a rudder, evidently changing their course by means of the hind feet.

I noticed on the lodge a pine pole about ten feet long, the small end evidently cut by the beaver, this end seeming to be about two inches through, and the butt three inches or more. There was a green alder branch on the top which was quite fresh on July 28.

On the way back to camp we stopped a few minutes by Pond No. 5 of the Elk Creek Bench group, where we saw two or three more beaver. Mr. Henry Lambert told me that he had seen "kits" there about a week previously. But some two or three weeks later he expressed the opinion that these supposed kits were really muskrats, as he did not see them again.

On August first I made a third visit to the beaver ponds, taking a party of tourists, three ladies and one man. We arrived there about 4 p. m. My first move was to set up a camera on Dam No. 2 at about the same place as the day before, but I placed it low down on a board instead of on the tripod, hoping the beaver would not be so much alarmed by it. I then measured along Dam No. 3, locating the various openings on either side. That done, the waiting for the beaver began.

They were late, not appearing until nearly 5:30, but after that time there were always some swimming about in the pond. My observations on the swimming were much the same as on previous days. One came along towing an aspen stick three feet or more long, with part of the bark eaten off (Fig. 127). It dived under Dam No. 3 with it and was not seen again. They did not come through No. 3 into the pool above as much as on previous days,— only once or twice.

It was not until the sun had gone down behind the high hills to the west that they began bringing food to the lodge,— willows from below the dam, and aspens from the hill slope on the west. It should be explained that while the sun went out of sight behind a hill about six o'clock, it did not actually set until much later, and it was light until eight.

The animals did not like the new arrangement of the camera much better than the previous one, and did not go over the dam until it had been removed.

My companions could hear the young cry in the lodge, and one lady said it was something like the note of a mourning dove. Mr. Mills had said the day before that it was like a young puppy, without the squealing note of the puppy, and she agreed with this, but did not think it like the cry of an infant, to which some have compared it. One of the other ladies thought it was like the puppy. The gentleman in the party thought it was like the grunting of young pigs ten to fourteen days old, but without the squeal of the pig. As I could not hear them myself I have no opinion to express.

Several times in bringing food from the west hillside the beaver would turn in behind some logs in the water near the south side of the pond, and when it reappeared it did not seem to have so large a load as before. Another beaver, apparently a yearling, would sometimes follow the first, and a little later would be seen feeding on green stuff near this place. Of course, these were not necessarily the same individuals seen at the different times.

One large beaver was observed to come from a hole in the hill near the east end of Dam No. 2, the same into which we saw brush carried the last thing on the night of July 28.

On August 17 I visited these ponds for the last time, and watched there from about 4:30 to 6:30 p. m. The beaver did not appear until about 5:30, and from then on there were always a few about, but not so many as on previous occasions. They also kept mostly toward the westerly part of the pond. An adult made three or four trips up the hill at the west end, returning with small aspens. It would then swim with these around to the southerly side of the pond, about opposite No. 4, where it would either be followed or met by yearlings, which received the food. This feeding of the yearlings by the parents was a new thing to me, something which had escaped my notice at the Yellowstone Bridge colony in 1921, if it occurred there at all. No food was taken into the lodge, though the young were heard there before we left.

I saw Mr. Lambert at Mammoth Hot Springs the evening of August 27, and he said he had been to the ponds an evening or two previously, and that the young beaver did not appear, although he could hear them in the dam and in the lodge. He was much puzzled about it, and thought it not unlikely the parents would not permit the young to come out while people were around. The party were on Dam No. 3.

This date is several days later than when we first saw the young beavers at the Yellowstone Bridge colony in 1921. That season they appeared on August 22, although there were many people about, and as close as at the other place. Mr. Lambert's explanation, which in fact is the one which had occurred to me, seems the most plausible, and it may have been the reason why the youngsters did not show up at the Yellowstone Bridge works until the above date, for they were so large then — the size of a large muskrat — it seems improbable that they had been kept in the lodge all this time.

I have looked up this matter in the various books at hand, and the only author who makes any definite statement as to the time when the young first appear outside the lodge is Enos Mills, who states that he had seen them in May.

Miscellaneous Notes on Behavior. I had many conversations at Camp Roosevelt with Mr. Henry Lambert, an old-time hunter and trapper who has spent much of his life in the Yellowstone region and has acquired a wealth of knowledge on the habits of the native animals. The following notes are from information obtained from him.

He related that a young beaver which he had kept alive used to always sit with its tail under and in front of it, and used it as a table, placing food or anything else it might have upon it. It slept in the bed between him and his boy, and about the middle of the night always woke up and wanted something to eat. They kept a fresh branch or two at hand for it, and when it had finished eating it crawled back into bed and went to sleep again.

He also said he thought that in winter the beaver preferred to take their food to a burrow for eating, rather than into the lodge, because dragging the sticks in and out enlarged the openings so much. That burrows used for dining rooms were always much larger than others for this reason. These places could be located if the ice was clear enough to see through by the discarded sticks downstream from them, where there was any current to carry them along.

In winter trapping he introduced the trap, after setting, into a burrow by putting the end of a long limber stick through the ring in the spring, and thus

could push the trap some distance into the hole, and then a little manipulation of the stick would free it from the trap so that it could be withdrawn. Burrows were not infrequently so high that the beavers would swim over a trap without touching it. It was useless to set it in the feeding burrows for this reason.

RELATIONS OF THE BEAVER TO OTHER ANIMALS

Animals that Frequent the Beaver Ponds. Frogs and garter snakes are abundant along the margins of the beaver ponds and canals. During one trip to the North Fork of Elk Creek (July 20, 1921) several garter snakes were watched in the act of slowly swallowing frogs. Trout were observed in these Elk Creek ponds, and especially in Pond No. 2 where they were seen jumping continually on July 12. Beaver ponds doubtless have an influence on bird life, attracting water and shore birds, as well as some species of the other orders which prefer such surroundings as the ponds offer. Mr. Skinner records ('25, p. 100) that the tops of beaver lodges, provided the lodges are surrounded by water, are favorite nesting sites of the Canada goose in Yellowstone Park. This location is evidently for protection against predatory animals. On August 29, at Beaver Lake Meadow we saw a great blue heron, mallards, and a marsh hawk. On August 25 we counted 22 mallards at the Lava Creek roadside pond, and observed also a kingfisher (in the act of swallowing a fish), a spotted sandpiper, and a great blue heron. Adult mallards with broods of young are to be seen each summer at this pond, and are one of the attractions for passing tourists. Mallards and other wild ducks were observed at several other beaver ponds; and eared grebes were noted on the natural pond northeast of Crescent Hill. Spotted and solitary sandpipers were frequently seen in the large pond at the Elk Creek Bench colony after the water became low enough to expose mud flats, and were also noted at the Petrified Tree colony ponds and elsewhere. An old pond, such as that at Crescent Hill, may support much aquatic vegetation which would be favorable to bird life. I have been surprised that I saw no ducks or grebes on this pond. Thick growths of brush along the shores of ponds would be attractive to some species of small birds, but there was little of this at the ponds in the Yancey region.

Muskrats were seen about some of the beaver ponds, but not nearly so frequently as I had expected them. At the Yellowstone Bridge colony a family lived in Pond No. 7, apparently having their burrow just above the lodge, and muskrats were also seen at other ponds in the group. At Pond No. 15 on the North Fork of Elk Creek these animals were also seen, and a dead young one was found by the dam in the large pond at Crescent Hill and another near the lodge at the large Tower Creek colony. I saw no signs of this species at any other of the colonies although they have been reported at Lost Lake.

Field mice of the Genus *Microtus* were occasionally seen near the beaver ponds. The little mountain meadow mouse, *Microtus nanus,* was the one seen, but *M. mordax,* the Rocky Mountain meadow mouse, should also be there, for I saw that species about my cabin at Camp Roosevelt. Jumping mice (*Zapus princeps*) were quite frequently surprised in the long grass near some of the ponds, making their escape when startled with the long leaps characteristic of these animals. They seemed quite abundant in 1923.

On the North Fork of Elk Creek woodchucks were hanging about the old beaver burrows exposed on the bank of Pond No. 3, if not actually using them. They used the top of the old lodge below the Petrified Tree Road as a basking place, but had their homes elsewhere on the hillside.

As mentioned in the account of the Upper Lost Creek Colony, a skunk was seen drinking at the stream, and went into an old beaver burrow, entering it at a place where it had broken through to the surface. Judging from the deliberate directness with which it went to the hole and entered it, I concluded that this was its home. I should think various animals might find these old broken-in burrows useful as refuges, if not dwelling places.

The various big game animals — deer, elk and moose — come about the ponds at times, perhaps to drink, or to feed on the grass or browse on the brush. Though seldom seen doubtless the predators frequent these beaver haunts, especially at night when the beavers are most busily engaged in foraging or building their works. Mr. Skinner noted bear tracks around the ponds at the Yellowstone Bridge colony in 1922; and in 1923, after the colony had been temporarily abandoned by the beaver a family of mink took up its abode there, and one or another of the animals was frequently seen by passers-by.

The Enemies of the Beaver. No first-hand information was obtained as to predatory animals that are enemies of the beaver. Mr. Henry Lambert, a trapper of many years' experience, told me that he thought mountain lions or cougars, wolves, coyotes, lynxes, wolverines, and possibly bobcats, all prey on the animals. He did not know of otters doing so, although others include them in the list of the beaver's foes.

On August 21 Mr. Lambert informed me that a couple of days previously he had found at the Yellowstone Bridge Colony the remains of a beaver which had been killed by some predatory animal, or animals,— for he thought from the indications that more than one was concerned in the killing, as there was evidence of a considerable struggle. The beaver evidently had been attacked either going to or returning from the aspens above the road. I saw nothing there the next time I visited the place, a day or two later.

Such dangers as this may well account for the abandonment of that colony the following year. The gait of the beaver when on land is such a slow, awkward waddle, it is not surprising that its enemies are able to capture it; for when out of water it appears to be absolutely defenceless. When attacked, beavers seem to make no attempt to defend themselves with their powerful incisors, which are nevertheless capable of inflicting severe wounds.

As mentioned above in the account of Lost Lake, the remains of a beaver killed by some predatory animal, most probably a coyote, was found on the shore of the lake in 1923. The skull and a few of the other bones were found.

FOOD AND FEEDING HABITS OF THE YELLOWSTONE BEAVER

Food Habits in General. It is well known that the beaver's food preference is for the bark of trees, especially that of deciduous trees. In this respect the Yellowstone beavers do not differ from those of other regions. Of the various trees, the aspen is the favorite. The animals will often pass by any other tree or

shrub when this is available. It is the inner or cambium layer of the bark which appeals to them most, yet I have seen many instances where no portion of the bark, not even the tough outer layer of large trees, was wasted, none being left about the logs. In my account of the Crescent Hill Colony I have described in detail how the inner bark of the Douglas fir was taken (see p. 97).

In feeding, the animals occasionally gnaw the bark from standing trees, but usually the tree is cut down, the branches lopped off, the trunk cut into lengths, and all carried to the water where the beavers can eat in safety. In winter the sticks are taken from the food pile into the lodge or burrow. When the bark has been eaten the sticks are taken out and left in the water. At other seasons they are sometimes placed on top of the lodge, on the dam, or left to drift where they will. In feeding the stick is held in the fore paws, somewhat as a squirrel holds a nut or a pine cone, and the gnawing goes on vigorously.

While the beaver must rely chiefly on the bark of trees for its sustenance, it exhibits considerable adaptability in its food habits. Throughout its range aspen is its favorite tree, but it commonly resorts to birch, cottonwood, willow and alder. In the Yellowstone region one species of birch (*Betula fontinalis*) occurs, but it is uncommon and a shrub no larger than the alder. In the Yancey meadows it was found at the west edge of the meadow below the main old dam, but dwarfed to a foot or so high, apparently from being browsed by elk rather than by the beaver. The latter were cutting some of the clumps of small willow sprouts close by.

While the bark of trees undoubtedly constitutes the bulk of its food, the Yellowstone beaver also eats other vegetation in summer, including various species of shrubs, grass and herbs. Willow bark and twigs are commonly eaten, but willow was by no means so important an item in the diet as in some other places where I have studied these animals. I saw a number of alder cuttings, but in only a few cases did the bark seem to be eaten very much. In the Yancey region not many willows or alders were cut, presumably because the favorite aspens were usually easily available. Along the Yellowstone River just above the Calcite Springs, alders 3 or 4 inches through had been cut and considerably stripped of bark. On Carnelian Creek, where the willows and alders are abundant and the aspen rather scarce, the former are being used extensively in the new dams, but cuttings for food were not especially noted. Willow sprouts were being cut and eaten at the Yellowstone Bridge Colony, in the Yancey meadows, and on the North Fork of Elk Creek, but not in large quantity. On several of the beaver streams studied a considerable growth of low willows is available, notably on Carnelian Creek, and on parts of Upper Lost Creek and the North and South Forks of Elk Creek.

A considerable variety of other plants were seen to be used for food, and I am inclined to think that as a matter of fact the beaver takes almost any green plant it finds during the summer season. The following were actually seen to be eaten at the Yellowstone Bridge colony: cow parsnip, wild rose, wild geranium (two species), choke cherry, grass, bedstraw (*Galium*) and Solomon's seal. Of these, the wild rose bushes seemed to be the favorite, and the animals used to cut large bunches of them which they brought down to the pond to eat in safety. They also often carried these bundles of shrubs or even bunches of grass under

water and into the lodge. Vernon Bailey ('18, p. 65) speaks of beaver eating grass on the banks of a stream in Glacier National Park. The other plants appeared to be taken indiscriminately just as the animal happened to come across them.

At two different times beaver at the colony on the North Fork of Elk Creek were observed to be eating algae.

As stated in the account of Lost Lake, about the only food supply available there, aside from grass and other herbaceous plants, seemed to be the roots and pads of the yellow pond lily (*Nymphaea polysepala*), which grows abundantly in the lake (Fig. 26). The pads were occasionally seen to be harvested, and on one occasion taken into the lodge. But now the beaver have begun cutting the Douglas fir where it extends down to the shore on the westerly side of the lake.

A most unexpected source of food for the beaver are the tall thistles which grow abundantly on certain moist slopes or meadows. At the Crescent Hill series of ponds, about opposite Ponds Nos. 6 to 11, on the north side of the grassy swale, the beaver had gathered the thistles extensively, cutting them off close to the ground. Their distinct trails led from the little stream out to the thistle grounds, a hundred feet or so away.

Aspen as the Chief Source of Food. That the aspen is the favorite food tree of the beaver seems to be the case everywhere throughout its range, even when there are other deciduous trees available, such as birch, maple, etc. This is the impression I have gained from reading various authors. In the Yellowstone the aspen is the only large tree at hand, aside from the sparse cottonwoods and various conifers, and consequently the aspen woods and groves adjacent to the streams are suffering greatly from the inroads of the beavers. The great increase of these animals in the Park, due to the destruction of the predatory animals, has had much to do with this. I have gone into more detail on this point below.

Beavers will eat other food than aspen bark if they are obliged to, and often do so from choice, especially in summer. No doubt they are glad of a change in diet. Even in summer, however, they consume much aspen, and even when using other plants. This seems to show that they really prefer aspen. Under these conditions the continuation of the supply of aspen is a serious problem. If the beavers were not so largely dependent on this tree for their winter supplies it would not matter so much, but willows and alders are not plentiful enough about most of the colonies for the purpose, and therefore the aspen has to suffer.

Aspen bark is evidently the staple and perhaps the exclusive food of the beaver in winter here, though some willow may be used. On September 4, 1921, aspen boughs were found stored in a pond at the Elk Creek Bench Colony, the only winter food storage noted up to that date during the two seasons' study. It is very unlikely that any conifers are stored in the ponds for winter use. Aspen boughs and sprouts are a common summer food also in the Yancey region; sprouts or seedlings a foot or two high were frequently found cut, the leaves and tender wood as well as the bark apparently being eaten.

While preferring well drained soil, the aspen comes in ahead of other trees along streams and moist runs, harmonizing with the beaver's adaptation to a water environment. Under normal wilderness conditions, where the predatory mammals are not unduly restricted, the beaver cannot safely harvest trees beyond one or

Fig. 128 (5114). A lodgepole pine, 17 inches in diameter, cut by beaver beside the deep spring at Tower Creek works. Aug. 5, 1921.

Fig. 129 (6035). Douglas firs felled by beavers on south slope of Crescent Hill, near Pond No. 14. The branches and tops have been cut off and carried away and the bark eaten from the logs where they fell. July 25, 1923.

Fig. 130 (6034). A felled Douglas fir with two extra notches and the bark eaten off. Near Crescent Hill ponds, July 25, 1923.

Fig. 131 (6037). A Douglas fir with the bark gnawed from trunk and roots. The beaver had scraped the earth away to get at the roots. Near Crescent Hill ponds, July 25, 1923.

Fig. 132 (6030). A Douglas fir 6.2 feet in circumference, with bark 2 inches thick, partly girdled. Note the flow of resin, which does not appear to discourage the beaver. Crescent Hill, July 25, 1923.

Fig. 133 (6033). A Douglas fir felled by beaver, showing the bark removed above and below the kerf, apparently before cutting. Crescent Hill, July 25, 1923.

two hundred feet from its home pond or stream. The destruction of its chief food tree is limited to that extent, and as aspen reproduces itself readily by sprouting the new crop starts at once and grows relatively fast (see Figs. 14, 75, 91).

The Cutting of Conifers for Food. Where aspen trees are now scarce the beaver are using the bark of conifers, particularly Douglas fir, as already mentioned in the descriptions of the various colonies studied. The following résumé and additional notes indicate the extent of conifer cutting observed in the Yancey region and elsewhere in the Park. See also Figs. 105–113, 128–133.

At the Yellowstone Bridge Colony a single lodgepole pine, of about six inches diameter, that was left untouched during the wholesale cutting of aspen there in 1920 and 1921, was felled by the beaver in 1922, but was not barked.

At the Tower Creek works several lodgepole pines, six inches to a foot in diameter, were cut beside the Big Spring—one in 1921 and several in 1922 and 1923,—but apparently not for food or any other purpose. Two or three standing trees were partly girdled, and the bark removed may have been eaten. Although several acres of large Engelmann spruce there was flooded and killed, none was cut. A wind-thrown pine had had several of the roots severed and carried away by beaver.

At Lost Lake, where a heavy Douglas fir stand extends down to the shore on the northwest, there was no cutting of the fir until 1922 when a few of the smaller suppressed trees were cut and the bark eaten, mostly where they lay. By 1923 several lodgepole pines in the woods on the opposite side had been girdled, apparently by beaver. But porcupines also have been doing considerable girdling in these woods, and when the work is near the ground the difference is not apparent unless one observes carefully. Although there is a heavy stand of Engelmann spruce at the other end of the pond, no cutting was found there.

On the South Fork of Elk Creek, just above the Yancey cabins, considerable cutting of small spruce was done in 1923, with indications that the bark and twigs were used for food.

At the Crescent Hill ponds there was sudden and very extensive cutting of Douglas fir, now that the accessible aspen was nearly exhausted, and most of the bark was utilized for food where the trees lay. In the same season occurred the most extensive conifer cutting observed in the Park,—at North Crescent Pond, where nearly all the large Douglas firs along the shore were felled; but scarcely any of these were touched thereafter.

At the Lava Creek Roadside Colony were noted a number of beaver-cut lodgepole pines, up to 12 inches in diameter, felled previous to 1923. These had not been used for food.

Beside the pond at Lava Creek Side-Gulch Colony, in 1923, when the aspen was nearly used up, and none was to be had except by climbing the steep slope to the roadside above, the beaver were cutting and barking for food many Douglas firs, and gnawing the bark from the standing trees. These were up to 8 inches in diameter, and were conveniently located on the banks.

Along the lower Gardiner River, two or three miles below Mammoth, several large Douglas firs or cedars were observed to have been cut down by beavers in 1921. There were only a few scattered trees there along the banks.

The most extensive cutting of lodgepole pine observed, was located along the Lewis River, not far from Lewis Fall, and has been described fully on pp. 129–130. The most notable feature there was the extraordinarily high stumps, indicating cutting during the deepest winter snows, some years since. Evidently the bark was used as an emergency food. Saplings of blue spruce, scattered among the larger pines, had not been touched.

It seems fair to draw the conclusion that beaver can readily resort to Douglas fir for food, and to lodgepole pine in case of necessity, but that spruce is disliked and is seldom eaten.

In 1923, in addition to observations on the recent and conspicuous cuttings of Douglas fir, some examination was made of certain fellings of spruce along the Yellowstone River, most of which were made some years ago. These are described in the following notes.

Cuttings in Yellowstone River Canyon, Below Tower Creek. Mr. Henry Lambert had reported to me having seen Douglas fir trees attacked by beaver beside the Yellowstone River, below the deep canyon a mile above Camp Roosevelt, and I made an investigation of this, as from his description it appeared to be similar to that which I had seen at Crescent Hill.

This narrow section of the canyon is the one which extends from Tower Creek down past the "Needles" (Fig. 96), and it was just below this canyon that the work was found. All along here the river is narrow, rocky and swift, and it seemed an unlikely place for beaver to be, and I doubt if more than one or two were there.

I did find fresh evidence of the presence of the animals. An alder close to the water, 5½ inches in diameter, had the bark eaten in places up to three feet above the ground. There were some small peeled sticks on the shore here, but they looked somewhat waterworn. One had willow bark on it, and as there were no willows growing at this place it seems probable that they floated down from somewhere upstream.

Farther up, a fir eight inches through was girdled except for a space of seven inches. The bark was taken off 12 to 18 inches high, part of the cut being close to the ground. The bark was one inch thick. Another fir three inches in diameter was completely girdled for two feet, and a four-inch fir for 18 inches. A nine-inch tree was partly girdled. As at Crescent Hill the outer bark had been discarded and lay on the ground beside the trees. One could go no farther up the river here because of the sheer cliffs.

On the opposite bank I could see a few trees which had been attacked, one of them considerably larger than any on the left bank, where I was. The canyon becomes so much narrower and the water so much swifter above here that seemingly a beaver could not hold his own in it. Yet several Douglas firs were cut in the canyon above (see Fig. 96).

Mr. Lambert said he could not remember ever having seen similar work elsewhere, though he has had much experience as a trapper, and is observant. He was greatly interested when he found this and reported it to me at once.

Cuttings Along Yellowstone River, Above Tower Creek. On the left bank of the Yellowstone, one to two miles above the entrance of Tower Creek, are some

old beaver cuttings. I first saw these July 15, but had no opportunity to make any detailed examination. I noticed, however, that a number of Engelmann spruce trees had been felled. On August 4 I visited the place again, thinking possibly I might obtain some information bearing on the use of conifer bark by the beaver.

There were once a few large cottonwood trees growing here on the river bank, but the great majority of the trees were Engelmann spruce of various sizes, with a few Douglas firs and lodgepole pines. Alders grow here and there along the river bank. All the cottonwoods were cut, several, if not many, years ago. The stumps have the appearance of considerable age. One 8.2 feet in circumference was cut nearly all around, broke, and the trunk fell into the river, where it now floated in the water against the bank. This tree was hollow, the outside wood being 6 to 8 inches thick. This hollow heart was doubtless the cause of the tree breaking off as it did. The bottom of the cut was 18 to 34 inches above ground. Another cottonwood was found the cut on which measured 20 inches in height, and it was a comparatively small tree, nine inches through.

It was the work on the spruces which I especially went to see. A considerable number of these had been cut down on the flat near the river, all old work. I examined the trunks, many of which were bare of bark, with care, but could not get much satisfactory or reliable evidence that beaver had removed the bark, though I discovered several places on several of the trunks where the wood had been gnawed into a little. The trees cut varied in size from 2 to 9 inches through. From one good sized stump the log was missing, and that was the case with many of the smallest trees. The top had also been cut from a medium sized tree.

A spruce 15 inches in diameter, which had been blown down, had a notch which had been begun by beaver, perhaps a year ago. As the tree lay this notch was on the under side. A nine-inch spruce had had the bark removed from a patch within a few months. An 8½-inch spruce was about three-fourths girdled, this work done within a year. The chips of outside bark were on the ground about the tree.

It must be admitted that this is decidedly unsatisfactory evidence of the beaver actually cutting spruce trees for food. The recent work, except in the case of the above mentioned fallen tree, may possibly have been done by a porcupine, evidence of whose presence I saw elsewhere, and the other work was too old to be of much use for study.

I continued up the west bank of the river beyond the point where Quartz Creek comes in on the east, and found old cuttings of alder and cottonwood, and now and then a felled spruce along the bank. From the fact that I found an occasional freshly cut willow or alder branch at the water's edge I judged that a lone beaver must be wandering about there.

Numbers and Disposal of Felled Trees. The number of trees felled by the beaver in relation to the number actually utilized for food, and the usual proportion of waste, can be readily ascertained; but the amount of food actually required is a more difficult matter necessitating observations in many localities extending over a series of years, before satisfactory conclusions can be drawn.

With this in mind I counted and marked in 1921 all of the stumps of trees cut at the Yellowstone Bridge colony up to September of that year. This would

enable later observers to ascertain the amount of fresh cutting in succeeding years. I counted and marked 316 stumps by driving a piece of iron pipe into the wood. In addition a good many stumps not counted were unquestionably very old. As stated in the account of that colony, beaver began work there about ten years ago. As we do not know the number inhabiting the place at various times we have nothing very definite on which to base any calculations as to the amount of food needed, and the same objection holds good with regard to all the colonies; we have no previous census of the inhabitants. However, the following year Mr. M. P. Skinner marked in a similar manner all the stumps of trees cut at this colony between the date of my marking and September 28, 1922. His total for the year was 158 trees, mostly aspens, but including a few alders and several cottonwoods. (See detailed table below, pp. 176–178.)

I counted 135 recent stumps on Lost Creek, and I doubt if this was more than a third of the actual number. The 61 stumps counted on Tower Creek were likewise only a small portion of the cuttings. At the North Fork of Elk Creek, on the west side of Pond No. 2 and above, there were counted 75 standing green aspens and 89 stumps. A count made later will give a little information, but not all that is desirable. As a matter of fact it is only at the Yellowstone Bridge colony that we have that most necessary item, the exact number of inhabitants, which was eleven. With a reasonably accurate knowledge of this point one can arrive at some conclusion as to the number of trees used by a single beaver. Without it we can only guess.

The beavers cut a good many trees which they fail to use (Figs. 120, 128). Some of those noted in the Yellowstone were aspens, and a number of conifers were seen, both lodgepole pines and Douglas firs, which had been cut and allowed to lie untouched. In the case of the aspens one can readily understand that the animals may have been frightened away, possibly killed, before they could use the trees, but as to the conifers it is quite different. While such fallen but unused trees are not numerous, they are not so uncommon as to escape notice. In no instance did I find any indication that these trees had been worked on after felling. The bark had not been eaten nor were the trunks cut into lengths for building material. It looks almost like wanton destruction. A pine seventeen inches in diameter had been cut close to the large spring on Tower Creek, and lay where it had fallen, not even a branch lopped off, and no apparent reason for the cutting (Fig. 128). Across the stump lay a small fir which also had been cut and not used. It is certainly puzzling why these trees are cut but left unutilized, and the habit forms one of a number of problems for which no satisfactory solution has yet been found.

SIZE, AGE AND GROWTH OF FOOD TREES

The following miscellaneous data on the age and growth of aspen and Douglas fir, the principal food tree species used by the Yellowstone beaver, were assembled in the summers of 1922 and 1923. The dimensions of stumps, logs, etc., as cut by the beaver are included for completeness. The ages of the trees were determined by counting the annual rings on the stumps; and in the case of standing trees, by the use of an increment borer.

Measurements of Trees, Logs and Stumps. *Felled Trees.* Various large felled trees were measured to obtain their lengths, primarily. At the South Fork of Elk Creek an alder, 4.5 inches in diameter and 36 feet long, had been cut. This is about the maximum size to which the alder grows in the Park. At the Elk Creek Bench group several large felled aspens were measured, and one * near the Yellowstone River, as follows:

Diameter	Length	Height of stump	Remarks
12 inches	45.5 feet	.....	Top cut off.
9 "	41 "	21 inches	"
12 "	47 "	42 "	"
10 "	52 "	18 "	Top uncut.
12 "	60 "	18 "	"
*6 "	38 "	24 "	"

Logs. Along Lost Creek some logs left at the trees where they were cut, measured as follows:

Diameter	Length	Diameter	Length
2.5 inches	3.4 feet	5 inches	5. feet
4 "	10. "	5 "	7.5 "
3 "	4.5 "	6 "	9. "
4 "	10. "	6 "	11. "
4 "	10.5 "	6 "	7.5 "
4.5 "	7.5 "	7 "	12. "
4.5 "	6. "	7 "	5. "

Poles in Dams. I made examinations and measurements of sticks on one or two dams, with a view to gaining definite information as to the size and character of material used. I also measured the length of various logs and cut trees which I found. At upper Lost Creek, on Dam No. 12 there were several unusually long sticks with the following dimensions:

Kind of wood	Diameter	Length
Dead aspen	2.5 inches	11. feet
" "	3. "	7. "
Live "	2.5 "	16.5 "
Dead "	3.5 "	11.5 "

A number of peeled sticks on the face of the dam measured as follows:

Diameter	Length	Diameter	Length
2.5 inches	54 inches	3. inches	48 inches
2.5 "	54 "	3.5 "	54 "
3.5 "	30 "	6. "	10 "
3. "	42 "	3.5 "	50 "
3. "	9.5 feet	4.5 "	60 "
3.5 "	30 inches	3.5 "	24 "
3. "	54 "	4.5 "	7.5 feet
2. "	29 "	3. "	22 inches
5. "	54 "	5. "	40 "

On the North Fork of Elk Creek at Dam No. 10, a number of peeled sticks on the face, 4 to 6 inches in diameter, varied in length from 15 to 60 inches. Two, each 5 inches in diameter, were 28 and 42 inches long respectively.

From the foregoing it would appear that there is no special relation between the diameter of the sticks and their length; that they are cut according to the whim or need of the animal, or its ability to transport the logs to pond or dam.

Stumps. In previous pages I have described the beaver's manner of cutting trees under different conditions, and the varying height of the stumps as studied on the North Fork of Elk Creek, upper Lost Creek, and Tower Creek (pp. 148–152); and in the case of lodgepole pine cutting, near Lewis River Fall (p. 129). My experiment of marking the 316 stumps counted at the Yellowstone River Bridge Colony in 1921, and its bearing on the question of food requirements of a known number of beaver, has been discussed above (p. 174). A record of all the fresh stumps was made by Mr. M. P. Skinner a year later. I quote in full the memorandum which he has kindly furnished regarding these observations and measurements.

"Since Mr. Warren marked the stumps that had been cut during 1921 and before, a measurement of stumps not marked now should give us a valuable record for the number cut from the fall of 1921 [Sept. 1] to this date, September 28, 1922 (i. e., one year). Mr. Warren's estimate of 8 adult beaver and 3 kits in this colony, I see no reason to doubt or amend.

"Measurements recorded below are from the ground where the worker stood to the center of the cutting, for height; and girth immediately below cutting on the stump, for circumference. All dimensions are in inches.

Cuttings North of Creek

Kind of tree	Height of stump	Circumference	Kind of tree	Height of stump	Circumference
Aspen	27	31.5	Aspen	26	17
"	20	23	"	24	10.5
"	24	25	"	17	17.5
"	31	16.5	"	24	15.5
"	20	22	"	17	12
"	23	17	"	11	11
"	20	21	"	14	11
"	21	18	"	20	12
"	20	20	"	16	16
"	10	25	"	15	18
"	14	16	"	22	20
"	14	13	"	19	15
"	9	15	"	10	13
"	24	8	"	16	24
"	28	16			

Cuttings Between Road and Creek

Kind of tree	Height of stump	Circumference	Kind of tree	Height of stump	Circumference
Aspen	17	16	Aspen	11	14
"	17	7	"	15	20.5
"	11	11	"	10	19
"	13	22	"	52*	17
"	24	14	"	15	21
"	9	20.5	"	18	13
"	14	16	"	18	23
Alder	29	16	"	18	11
"	19	17	"	16	15
"	29	14	"	6	20
"	11	17	"	20	26
"	11	10	"	26	11
"	12	8	"	22	11
"	15	14	"	18	10
Aspen	10	14.5	"	18	16.5
"	14	21	"	21	11
"	23	16	"	21	16.5
"	12	21	"	20	5
"	16	14	"	18	11
"	16	10	"	18	20
"	16	15	"	15	15
"	16	11	"	20	12
"	15	16.5	"	20	11
"	9	13	"	12	19
"	11	18	"	9	20
"	8	10	"	9	21
"	24	16	"	9	24
"	11	22	"	9	21
"	11	17	"	9	20
"	14	18	"	16	17
"	13	13	"	17	19
Cottonwood	16	34	"	24	17
"	12	25	"	17	13.5

*A bush stood beside the 52-inch stump, and it is probable that the beaver stood in the bush while doing the cutting.

Besides the stumps recorded above there were 14 more of alders less than 4 inches in circumference.

[It appears probable that the rather wide variation in the heights of stumps in these cuttings is due partly to winter work when snow covered the ground. The winter observations of beaver by Mr. Skinner and Park Ranger Bauman at this colony (see pp. 31–32), and by Park Ranger Demmink on Hellroaring Creek (see p. 190), corroborate my own evidence—from high stumps—of winter cutting activities along Tower Creek, North Fork of Elk Creek, and near Lewis River Fall (see p. 152).]

Cuttings South of Road

Location	Kind of tree	Height of stump	Circumference	Location	Kind of tree	Height of stump	Circumference
Directly south of road	Aspen	6	8	East of beaver trail	Aspen	6	19
	"	10	15		"	8	18
	"	11	19		"	27	16
	"	14	13		"	26	14
	"	14	12		"	33	11
	"	11	9		"	14	17
	"	12	17		"	15	19
	"	23	10		"	15	20
	"	14	14		"	15	17
	"	20	15		"	22	21
	"	22	14		"	11	16
	"	26	16		"	12	10
	"	26	8		"	27	10
	"	24	17		"	15	12
	"	37	12		"	12	17
	"	20	19		"	20	16
	"	20	19		"	17	17
	"	10	13*		"	14	18
Lowermost eastern cutting	"	15	19		"	16	17
	"	16	31		"	15	15
	"	19	20		"	14	11
	"	19	20		"	14	19
	"	14	20		"	12	19
	"	16	22		"	13	20
	"	16	18				

* The only freshly cut stump.

"Almost all the trees recorded above were cut in early spring before they had leaved out. The only freshly cut stump was a month old. Evidently the beavers have been feeding all summer on trees cut early, and on small vegetation. No sign of storage for winter at any point yet [Sept. 28]. Beaver were about there all summer, but now no fresh sign anywhere, and some of the ponds are drained. Both trails that cross the road lead to clumps of willows.

"The above record shows a total cut during the year of 135 aspens, 2 cottonwoods, and 21 alders. A few of these stumps recorded as aspens might have been cottonwoods instead, as the difference could not be told in the stumps of such small trees.

"The trunks and even branches of trees whose stumps were marked by Mr. Warren the preceding year were sometimes still lying on the ground untouched. The marking method used (driving the end of an iron pipe into the stumps) is far from permanent, and in a few cases the marks are already difficult to find."

Age and Growth of the Food Tree Species. The following tables (Tables 1–4) of diameter growth of the beavers' chief food tree species in Yellowstone Park—omitting willow, which does not grow to tree size here, and cottonwood and Engelmann spruce, which are negligible—are based on cores taken at breast height with an increment borer. The growth rings were kindly determined and the tables prepared by Mr. J. Elton Lodewick of the New York State College of Forestry. Extreme crowding of the annual rings over a period of several years (due to suppression of individual trees, fire, drought, etc.) was noticeable in some cases; therefore to secure an accurate count microscopic sections were made of all cores. The aspen cores were all taken from trees near Camp Roosevelt.

Table 1. Diameter Growth of Aspen

Tree Number	Total age, years	Diameter in inches	Diameter in Inches at 10-Year Intervals						
			10 years	20 years	30 years	40 years	50 years	60 years	70 years
1	40	2.80	0.96	1.76	2.56	2.80	.....	.....	.....
2	50	4.64	1.28	2.68	3.48	3.88	4.64	.....	.....
3	48	5.24	1.24	2.28	3.40	4.36	5.24	.....	.....
4	53	5.90	0.96	2.00	3.24	4.60	5.48	5.90	.....
5	50	4.12	0.96	2.20	3.00	3.56	4.12	.....	.....
6	50	3.44	1.12	2.04	2.60	3.08	3.44	.....	.....
7	46	3.72	0.84	2.64	3.20	3.48	3.72	.....	.....
8	37	5.00	1.20	2.56	4.00	5.00	.....	.....	.....
9	48	4.20	1.52	2.56	3.08	3.68	4.20	.....	.....
10	48	4.96	1.12	2.20	3.24	4.08	4.96	.....	.....
11	45	5.84	1.48	3.08	4.28	5.36	5.84	.....	.....
12	53	7.28	1.20	2.84	4.52	5.96	7.20	7.28	.....
13	50	4.92	1.20	1.96	2.82	3.68	4.92	.....	.....
14	63	7.84	0.92	2.40	3.96	5.20	6.24	7.36	7.84
15	48	6.24	1.60	3.28	4.52	5.52	6.24	.....	.....
16	46	4.84	1.32	2.24	3.32	4.12	4.84	.....	.....
17	40	3.64	1.20	2.36	3.36	3.64	.....	.....	.....
18	53	3.44	1.08	2.00	2.44	2.80	3.38	3.44	.....
19	50	3.96	1.36	2.28	2.84	3.54	3.96	.....	.....
20	54	2.84	0.36	1.12	1.76	2.24	2.72	2.84	.....
21	53	3.84	1.32	2.16	2.68	3.12	3.64	3.84	.....
22	49	5.48	1.52	3.40	4.20	4.80	5.48	.....	.....
23	54	7.04	1.96	3.72	4.80	5.56	6.32	7.04	.....
24	49	4.56	1.04	2.04	2.88	3.92	4.56	.....	.....
25	50	2.48	1.16	1.68	2.00	2.24	2.48	.....	.....
26	47	1.60	0.44	0.88	1.32	1.48	1.60	.....	.....
27	50	2.64	1.04	1.68	2.12	2.56	2.64	.....	.....
28	48	1.48	0.52	0.88	1.04	1.28	1.48	.....	.....
29	40	5.90	1.36	3.20	4.88	5.90	.....	.....	.....
30	50	2.40	0.64	1.16	1.42	2.04	2.40	.....	.....
31	49	3.08	0.88	1.68	2.36	2.72	3.08	.....	.....
Average diameter			1.12	2.22	3.07	3.75	4.33	5.82	.....

Note: In each case where a decade is incomplete, a uniform rate of growth is assumed for the whole decade in the averages. This holds throughout Tables 1–4.

Table 2. Diameter Growth of Alder

Tree Number	Total age, years	Diameter in inches	Diameter in Inches at 10-Year Intervals					
			10 years	20 years	30 years	40 years	50 years	60 years
1	34	3.28	1.04	1.88	2.92	3.28	.....	.....
2	46	2.88	0.36	0.72	0.80	1.76	2.88	.....
3	37	4.40	1.42	2.60	3.44	4.40	.....	.....
4	60	4.00	1.12	2.20	2.76	3.04	3.32	4.00
5	17	1.88	0.56	1.88	.....	.....	.....	.....
6	10	1.60	1.60	.....	.....	.....	.....	.....
7	60	4.04	0.48	1.28	2.08	2.56	2.92	4.04
Average diameter			0.94	1.86	2.40	3.20	3.29	4.02

Table 3. Diameter Growth of Douglas Fir

Tree Number	Total age, years	Diameter in inches	Diameter in Inches at 10-Year Intervals									
			10 years	20 years	30 years	40 years	50 years	60 years	70 years	80 years	90 years	100 years
1	44	3.52	1.36	2.65	2.74	3.20	3.52	....	....	....	....	.....
2	38	3.02	1.44	2.24	2.88	3.02	....	....	....	....	....	.....
3	39	3.00	1.12	2.00	2.80	3.00	....	....	....	....	....	.....
4	30	2.00	1.24	1.84	2.00	....	....	....	....	....	....	.....
5	41	4.56	1.76	2.88	3.88	....	4.56	4.52	....	....	....	.....
6	48	3.52	0.80	1.60	2.76	3.02	3.52	....	....	....	....	.....
7	40	4.00	1.40	2.20	3.44	4.00	....	....	....	....	....	.....
8	100	6.40	0.20	0.68	1.08	1.48	2.28	3.48	4.44	5.24	6.04	6.40
9	96	8.80	0.92	1.20	1.64	2.08	2.64	3.80	4.88	6.12	7.60	8.80
10	35	6.44	2.28	3.88	5.52	6.44	....	....	....	....	....	.....
11	80	6.95	1.08	1.52	2.16	3.16	4.52	5.80	6.00	6.95	....	.....
12	47	2.00	0.88	1.28	1.44	1.88	2.00	....	....	....	....	.....
13	40	4.60	1.21	2.60	4.24	4.60	....	....	....	....	....	.....
14	53	2.72	0.52	1.08	1.72	2.16	2.56	2.72	....	....	....	.....
15	38	3.24	1.52	2.28	3.08	3.24	....	....	....	....	....	.....
16	53	3.20	0.68	1.48	2.28	2.80	3.00	3.20	....	....	....	.....
17	53	2.40	0.64	0.76	1.56	2.16	2.24	2.40	....	....	....	.....
18	45	1.84	0.72	1.12	1.28	1.54	....	....	....	....	....	.....
Average diameter			1.10	1.85	2.58	3.19	3.30	3.77	5.11	6.10	6.82	8.00

TABLE 4. DIAMETER GROWTH OF LODGEPOLE PINE

TREE NUMBER	Total age, years	Diameter in inches	DIAMETER IN INCHES AT 10-YEAR INTERVALS				
			10 years	20 years	30 years	40 years	50 years
1	37	3.44	1.08	1.80	2.84	3.44	.....
2	43	5.76	1.60	2.88	4.08	5.40	5.76
3	48	6.08	1.64	3.04	4.28	5.40	6.08
4	45	4.00	1.08	1.80	2.88	3.68	4.00
5	36	3.00	1.20	2.04	2.68	3.00	.....
6	32	2.88	1.00	1.96	2.60	2.88	.....
7	45	6.24	1.52	2.72	3.92	5.56	6.24
8	33	3.12	1.16	1.56	2.44	3.12	.....
Average diameter			1.28	2.23	3.22	4.46	6.02

The following table comprises diameter growth data from a few dead aspens, probably killed by natural crowding, cut in the groves near Camp Roosevelt. The measurements were all made close to the ground.

TREE NUMBER	Age, years	Diameter in inches	TREE NUMBER	Age, years	Diameter in inches
1	12	0.87	6	23	1.75
2	12	1.50	7	25	2.12
3	16	1.12	8	26	2.50
4	20	1.50	9	32	2.25
5	22	1.12	10	34	2.12

In the Yellowstone region aspen reproduction probably always occurs by sprouting rather than by seeding (cf. Baker, '25, pp. 20–23). There were a good many very young aspens about Camp Roosevelt, which could be divided roughly into two sizes, evidently representing distinct age classes, as follows: small, 24–30 inches high, a few 36 inches; large, 54–60 inches high. The following table, based on a few of these measured close to the ground, indicates approximately the early diameter growth of sprouts on favorable sites in the Yancey region.

SPROUT NUMBER	Age, years	Diameter in inches	Average diameter	SPROUT NUMBER	Age, years	Diameter in inches	Average diameter
1	2	0.33	0.30	9	4	0.65	0.54
2	2	0.26		10	4	0.35	
				11	4	0.62	
3	3	0.30	0.36	12	4	0.55	
4	3	0.35					
5	3	0.38		13	6	0.55	.....
6	3	0.42					
7	3	0.34					
8	3	0.36					

THE NUMBERS OF BEAVER IN RELATION TO THE FOOD SUPPLY

A Provisional Estimate of the Beaver Population. The destructive work of the beaver suggests far greater numbers in a colonized locality than is actually the case. An example illustrating this is the Yellowstone Bridge Colony where a tremendous amount of cutting of trees and building of dams and ponds was going on for several years prior to 1922. But when apparently at the height of their activity in 1921, there were but two colonies, a total of eleven or twelve individuals, representing three generations. Only five or six of these could have been active workers. Mr. M. P. Skinner's observations show that in one year—"fall of 1921 to September 28, 1922"—the beaver in this colony cut 158 trees, varying from 2 to 11 inches in diameter (see pp. 176–178). Again, at Pond No. 2, the home of the beaver on the North Fork of Elk Creek, in July, 1923, there were only eleven beaver, representing two families. But the cutting and construction work at the present rate would soon exhaust the available aspen.

There seems to be no simple way of ascertaining the amount of food required to sustain a beaver or, more definitely, how many aspens of a given size it needs to carry it through a long winter. Enos Mills found that one colony cut over 700 aspen saplings for their winter supply, besides willows. He does not say how many animals were in the colony. The lodge was a very large one. In Colorado I found a mass of stored willow brush extending 100 feet along the shore of the pond, in water 4 feet deep, and piled up to the surface. These willows were from 3 to 8 feet long, and it will readily be seen that they represent much work as well as a large amount of food.

We may say that there were 200 beavers, more or less, in the colonies studied in the Yancey Region in 1923. I do not think this estimate is far from the truth. This number, or even half of it, would require much food, and when we consider the supply in sight in 1923, some of the colonies seemed bound to run short.

I give below my guess, I can hardly call it an estimate, of the beaver population of the Yancey region. I have estimated 8 animals to the lodge, and made allowances for those living in burrows.

Yellowstone Bridge Colony	11
Petrified Tree Road Colonies	20
South Fork of Elk Creek	8
Elk Creek Bench Colony	8
North Fork of Elk Creek	40
Natural Ponds	20
Crescent Hill Ponds	16
Tower Creek	50
Carnelian Creek	25
Lost Creek	25
Lost Lake	8
Along Yellowstone River	5
Total	236

This number of animals the size of a beaver, averaging we may say for young and old, 30 pounds each, must use a great deal of food, even though in winter they lead a very sedentary life, taking but little exercise, and therefore probably not requiring as much as in the summer season, when they are active.

The Present Problem of Overstocking. The beavers' rapid depletion of the aspen groves adjacent to streams and ponds presents a serious problem. These animals harvest a crop which takes many years to replace and of course do nothing toward replanting. Some data were gathered on the ages of different sized aspens, as already given in detail. It is sufficient to state here that it takes from twenty to fifty years to replace the harvested trees with new ones from two to five inches in diameter, which are about as small as the animals can use to advantage, at least for winter food. The aspens 9 to 12 inches in diameter, mentioned as having been cut at Elk Creek Bench Colony, were probably 80 to 120 years old. It takes an aspen about 150 years to attain a diameter of 14 inches, 225 to reach 18, and 270 years to grow to 20 inches in diameter. The cutting of such large trees destroys the work of one or two centuries, and even more. Meanwhile, what are the beavers to live on? In summer, of course, they can and do obtain plenty of other green food. For winter use, however, they must have woody trees or bushes. In most of the beaver haunts which I have seen in Yellowstone Park the supply of available willow brush and alders is relatively small, by no means enough to maintain their present numbers.

There has doubtless been a great increase in the number of beaver in the Yellowstone Park of late years. The protection from molestation by trappers is certainly a very important factor in this. The killing of predatory animals undoubtedly has had much to do with it, especially within the last few years. When over two hundred coyotes are killed in a single season, as in 1922, the animals which formed part of their food are bound to profit by it and to increase in numbers. The result has been what is probably an unnatural expansion of the beaver population. In consequence of this there is a rapidly diminished food supply. It is the old story of disturbing the relative balance of Nature. The coyotes are killed to preserve the big game, but incidentally all other animals on which they preyed are likewise preserved, inducing overstocking of certain species.

There was hardly a beaver colony which I visited in the Yancey region where the supply of aspens was not practically exhausted, with no more near enough to be harvested without too great labor and danger. At the Crescent Hill colony the animals were using the inner bark of the Douglas fir as well as that of the remaining aspens. I have already referred to this in my remarks on that colony, and have nothing to add to the opinion therein expressed that the beavers were doing this rather than abandon the old home, even though there was a good supply of aspen a little farther down the gulch. Possibly they found they could not make satisfactory ponds below, especially during dry seasons.

The situation at the natural pond on North Crescent Creek (see p. 102) suggests a different interpretation. The available aspen had been destroyed long ago, and the pond and dams apparently abandoned. But in 1923 there was suddenly a wholesale cutting of the scattered Douglas fir timber along the shores, trees up to a foot and a half in diameter and probably 75 or 100 years old, untouched through all those years. Correlated with the unusual cutting of Douglas fir elsewhere in the

Yancey region, may not the return to this old haunt, and the unusual cutting of conifers, indicate that the beaver has suddenly formed a new food habit? May it not represent a local acquired habit as a result of the depletion of aspen?

Elsewhere, very large aspens were being cut, these being the only ones left. With these gone, the beaver must move out. Excepting possibly along Tower Creek, the sizable aspens are exhausted along most of the streams of this locality, or will be very soon.

There are saplings and sprouts, two to five feet high, growing near a number of the ponds, and in the summer many of these are cut for food; and the beaver seem especially prone to taking them into the lodge for the young. Cutting these young trees destroys the potential future supply of food. Frequently where young seedling or sprout growth in dense patches has come in following the cutting of the aspen, it has not been touched (Figs. 75, 91). This is especially hopeful in areas already abandoned, or where the old trees were cut during sporadic wanderings. Whether any of this very young growth is ever stored for winter use I do not know, but doubt if such is the case.

Where the beavers can go when they abandon their present colonies is a serious question. I believe that every stream in the northeastern region of Yellowstone Park which has a supply of aspen available is already occupied by colonies. For the emigrants from depleted areas to crowd in on these would only result in hastening the exhaustion of the remaining food supply.

From the esthetic standpoint, it would seem scarcely advisable to allow the beaver to cut all the large aspen bordering the Park streams and ponds or to flood every convenient spruce flat,—as for example, at the Petrified Tree Colony and on Tower Creek, where several acres of fine Engelmann spruce forest probably a hundred years old has been drowned in the process of making ponds during the past few years. Unless a natural balance among the Park animals can be maintained, and the beaver population kept at a constant normal figure, we may expect recurrent cycles of gradual stocking with aspen and beaver followed by rapid exhaustion of the food supply and dispersal of these animals elsewhere.

Possible Measures for Maintaining a Natural Balance. I have given the matter considerable thought, and believe that some steps must soon be taken to remedy this apparent congestion of the beaver population.* They may be necessary in only a few places, as the Yancey region, or they may be necessary over a large portion of the Yellowstone Park. Further study is necessary to determine this for the Yellowstone as a whole, in the interests of wise future management.

The only practicable method seems to be to capture some of the animals and dispose of them outside the Park. I do not advocate trapping them in a National Park for their pelts. I think a limited number should be taken alive and distributed to nearby National Forest areas and to zoological gardens. It might be well to sell some either to dealers in live animals or to persons desirous of attempting the breeding of beavers commercially, i. e., establishing "beaver farms." If this trapping alive were done judiciously, and not too many taken from any one colony, I believe it would be of much value in adjusting the matter. Unless only

* Observations made during 1925 indicate that there is no longer a surplus of beaver in the Yancey region. They have evidently scattered to other localities, though a few remain on all streams, in adjustment with the food supply. See pp. 31–32; and Addendum, pp. 187–191.

the yearlings are taken this work should not be done until late in the season, in order that the parents may not be separated from the young until the latter are able to care for themselves; and even so, I think the wiser plan would be to take only the yearlings.

Capturing the beaver alive and disposing of them for breeding purposes with the object of raising the animals on a commercial scale for the production of fur, has the possibility of aiding in the establishing of an industry which might in time prove of considerable importance to the fur trade. To be sure, beaver ranching or farming is as yet in the early experimental stage. The United States Biological Survey has published a bulletin on beaver farming which gives many useful hints concerning the habits of the animal and for beginning such work (Bailey, '23). In practically all of the western states, as well as in the East, trapping of beaver is prohibited by law, except in special cases, so that it would be difficult for prospective beaver farmers to obtain the necessary breeding stock. It is possible that if beaver farming proved to be practicable, the states might permit the taking of live beaver for the purpose. At present we cannot expect this, and the National Park Service might aid greatly in making a beginning by disposing of its surplus stock at a nominal price.

A purpose for which the surplus beaver might well be used is the restocking of streams outside the Park where beaver have been exterminated and where conditions are satisfactory for their maintenance. This was successfully done in the Cochetopa National Forest, Colorado. But the distribution should not be promiscuous and thus mix up faunal problems.

It seems very probable that a certain number of beaver annually leave the Park by following the Yellowstone River and other streams beyond the boundaries, and thus replenish the stocks in those streams, which, however, are no doubt constantly reduced by poachers in spite of prohibitive laws.

SUMMARY AND RECOMMENDATIONS

1. In general, there are constant and rapid changes occurring in the beaver works, with frequent abandonment of colony sites and relocation on fresh suitable areas. The study and mapping of identical colonies, first in 1921 and again in 1923, show the character and rapidity of these changes, and indicate about what is to be expected with beaver elsewhere in the country.

2. The detailed surveys in the Tower Fall-Yancey region furnish a base upon which further later examinations may readily be made, looking toward the solution of a number of problems on the relation of these animals to their environment and the requirements for their successful maintenance and management.

3. The observations made on the beaver's relation to topography and stream flow, and its tree-cutting and engineering habits, afford some basis for determining localities suitable for introducing beaver, and indicate what effect they will have on local conditions, including the streams and adjacent woodland.

4. Observations on the beaver's behavior and on its animal associates show that a number of birds and mammals either live in harmony with it at its ponds, or prey upon it, suggesting a close interrelation that should not be disrupted in a wilderness park.

5. A study of the feeding habits shows that aspen is the beaver's chief source of food, but that sometimes, under a system of strict protection, beaver will resort to conifers, cutting them in large numbers rather than abandon their home locality.

6. The data secured on age and growth of aspen give a rough idea of how soon the beaver may ordinarily be expected to re-locate (as a colony) on an area once denuded of trees. This cannot be less than 20 years, as the regeneration of aspen large enough for a food supply requires from 20 to 50 years. It seems apparent that on new areas with abundant food trees the waste is excessive.

7. The present indications are that the Yellowstone Park is already overstocked with beaver; for *available* and sizable aspen along suitable streams is being destroyed faster than it is being replaced in other accessible areas. The small willow growth may be sufficient to support a colony here and there. As conifer bark is evidently used only in emergencies, and probably is not stored for winter food, it will not serve to maintain a colony.

8. To restore and maintain a natural balance, so far as the beaver are concerned, it may be necessary to refrain from killing the predators as closely as at present. Also, it is recommended that any surplus beaver be disposed of alive in some way, as the Park is a wild life sanctuary and commercial killing is not to be considered. As a preliminary measure a limited number of yearling beaver might be trapped on each stream and used for colonizing other suitable regions, especially in the adjacent National Forests.

9. It is recommended that future beaver investigations in the Yellowstone region be conducted along the following lines: (1) periodic repetition of survey and comparative study of the areas already mapped; (2) exact studies of the growth and regeneration of aspen; (3) determination of the amount of food actually required by beaver, and the proportion of waste in unrestricted cuttings; (4) seasonal and other migrations of the beaver and their causes; (5) further study of interrelations with other species, and especially with predatory mammals, looking toward the maintenance of a biological balance in the Park.

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ADDENDUM

In the account of the Yellowstone River Bridge Colony I have already quoted notes by Park Ranger John Bauman and Mr. M. P. Skinner for 1924 and 1925 (see pp. 31–32). These further notes from observers in the Yancey region in 1925 are of interest as supplementing our earlier observations. On August 24, 1925, Mr. A. G. Whitney was able to visit several colony sites during a hurried tour of the park. He describes the conditions found as follows:

"The day was clear, with showers early in the afternoon. My companion and I at 11 a. m. proceeded by automobile out to the west end of Crescent Hill, then climbed over the crest of the hill to examine the spruce budworm infestation

in the Douglas fir forest on the east side. This had resulted in the destruction of large stretches of timber, culminating in 1923; and as the beaver had begun feeding on the bark of Douglas fir near the ponds in that vicinity, it seemed to bear on their problem. Now, however, the 'epidemic' appeared to have spent itself entirely. In a depression on the open top of Crescent Hill we surprised a pair of coyotes engaged in worrying a pile of old bones. They raced away over the crest, but from the manner in which they followed and serenaded us during the next two hours I judged this was their home territory. Signs of grouse were frequent in the fir woods as we descended the rocky slope to the Crescent Hill series of old beaver ponds, and this may have been the special attraction for the coyotes.

"We first examined Pond No. 14, walking clear round it and searching for all possible signs of beaver. The weather had evidently been unusually dry. There were no signs of seepage into the pond from springs above, and the water was a little lower than in 1923. The works had plainly been abandoned for a long time, and the only recent evidence of beaver comprised two Douglas firs, not over 4 or 6 inches in diameter, which had been cut 30 or 40 feet back on the upper west side, perhaps six months previously. All the 1923 cuttings appeared as if no further work had been done there since Mr. Warren's examinations. The upper ponds and dams were more delapidated and grass-grown than ever, and probably will not be again occupied by any but wandering beaver, at least for many years. A flock of about 15 mallards flew up from the lower part of the pond. The rest of the upper ponds were now wholly dry, as well as the swale below. Opposite the former Pond No. 11 we examined the wreck of the aspen grove [shown in Figs. 68, 71] that had been nearly cleared out in 1923. Several of the trees on the upper edge were still standing, and the felled ones looked as though abandoned suddenly in the midst of operations, as did the fir cuttings already mentioned.

"Following the dry grassy run down to the lower series of ponds, we found no swampy ground, and only a little water in one pond, No. 6. There was a tangle of old wind-thrown aspens just above this pond. The large aspens beside the pond were standing untouched; no indications of beaver having been there recently. Opposite Pond No. 6, on the east, the considerable grove of tall, thrifty aspens was still intact, except that several trees had been wind-thrown,—torn up by the roots. Evidently the drought has prevented the beaver from continuing a colony here; but with the advent of an unusually wet season they will very likely again colonize the springy run for a season or two and destroy the bulk of the remaining aspens.

"We walked across the divide to East Crescent Pond, the pair of coyotes still howling along the wooded slope in our rear. As we approached the shore of this natural pond, the water of which appeared to be at about the same level as in 1923, two flocks of ducks rose and circled, then settled quietly again in the water. On the mud flat extending out into the pond several Canada geese were basking and sleeping in the noonday sun, and a great blue heron stood statue-like close by. The groves of large aspen at the upper end of the pond remain as we saw them in 1923, except that two or three of the very large trees had been felled very lately. These lay with their trunks suspended a couple of feet off the ground.

Muddy, well worn trails led to them through the rank grass; and besides cut branches we noted that the under sides of the trunks had been freshly barked where the beaver could reach them. Apparently no more than a pair of the animals were at work here.

" Unfortunately we had no time to examine the other colony sites near by, but noted at Yanceys that a wooden sluiceway has been constructed to conduct the water of Elk Creek from the gorge along the rock slide to the hay meadows. The haymakers at work there informed us that the beaver dams above the cabins, on the South Fork, had been torn out and the water likewise utilized for irrigating the meadows.

" Continuing on to Mammoth Hot Springs by automobile, the Lava Creek Roadside Pond still appeared as a slough merely, and doubtless the beaver have had no reason to repair the dam torn out in 1923. But they have been active just below in the dense willow thickets along the creek, where, above the highway crossing, they have constructed a new dam of willow brush, perhaps six feet high. Farther on, the Side-Gulch Colony as seen from the road showed no signs of occupancy."

Under date of November 14, 1925, Park Ranger John Bauman writes as follows, in a letter to Mr. Whitney:

" As near as I can tell the beaver at the ponds near Yanceys (South Fork of Elk Creek) are not as plentiful as formerly. They seem to have moved to the small stream coming from near the west end of Lost Lake and running past the Petrified Trees, near which they have a series of dams. At present there are only about two beaver at the ponds near the Yancey cabins, and they are doing no new work. They are using the old hut and are pushing the waste over the dam. As to these beaver cutting spruce or fir, I am sure it is only spruce. Most of the beaver left these ponds in the fall of 1923; I am confident it was because the quaking asp is gone from the vicinity,—unless they go up on the west slope and a long way from the stream.

" The new dams on the little stream running west from near Lost Lake are among the most interesting ones I have ever seen. The beaver there seem very tame, and they have given many a thrill to the tourists in the Tower Falls district this past summer, visitors from Camp Roosevelt going there every evening to watch the beaver swimming around. They have a series of dams, six in all; the one in the center is where the home is, and from there they come and go frequently. Starting at the lowermost dam, the water is on a level with the bottom of the next dam above, and so on up the stream. One would almost say it was a series of canals. I have watched them take quaking asp up this stream through these canal-like ponds, over one dam after another until they reached the hut. Late this summer, about September 15, I myself cut 12 aspens about 5 inches through and placed them near the pond where the hut is located. I went back the next day, and these beaver, about 8 in number, had already taken one-third of the full amount into the pond. They seemed to lay or fasten it under water near the hut. They were eating little if any of the bark of these aspens that were being cached in the main pond. Everything indicated that they were storing them for winter use. I gathered this to be the case because they had pushed out no new wood from which the bark had been eaten.

"The beaver in the ponds along the very small stream flowing north from the east side of Crescent Hill [North Crescent Creek, see p. 102], which we examined in late August, 1923, have moved upstream to some small groves of quaking asp. So far as I could see they cut no more Douglas fir after the above date when we observed so many firs freshly cut along the shores of the permnant large pond lower down. They ate or barked very little of what fir was cut. That same fall they left for the upper part of the rivulet, where they now have some nice dams.

"Apparently two beaver have taken up the old dams just above the fall on Lost Creek. They came in there late in the autumn of 1923 and have a nice dam set up."

I had anticipated the return of the beaver to that section of Lost Creek, for considerable aspen was still available there at the time of my last visit, August 16, 1923.

The following account, by Park Ranger Gerrit Demmink, of recent beaver activity on Hellroaring Creek, several miles north of Yanceys, is taken from "Yellowstone Nature Notes" (issued monthly in mimeographed form by the officials of Yellowstone Park), under date of January 2, 1926.

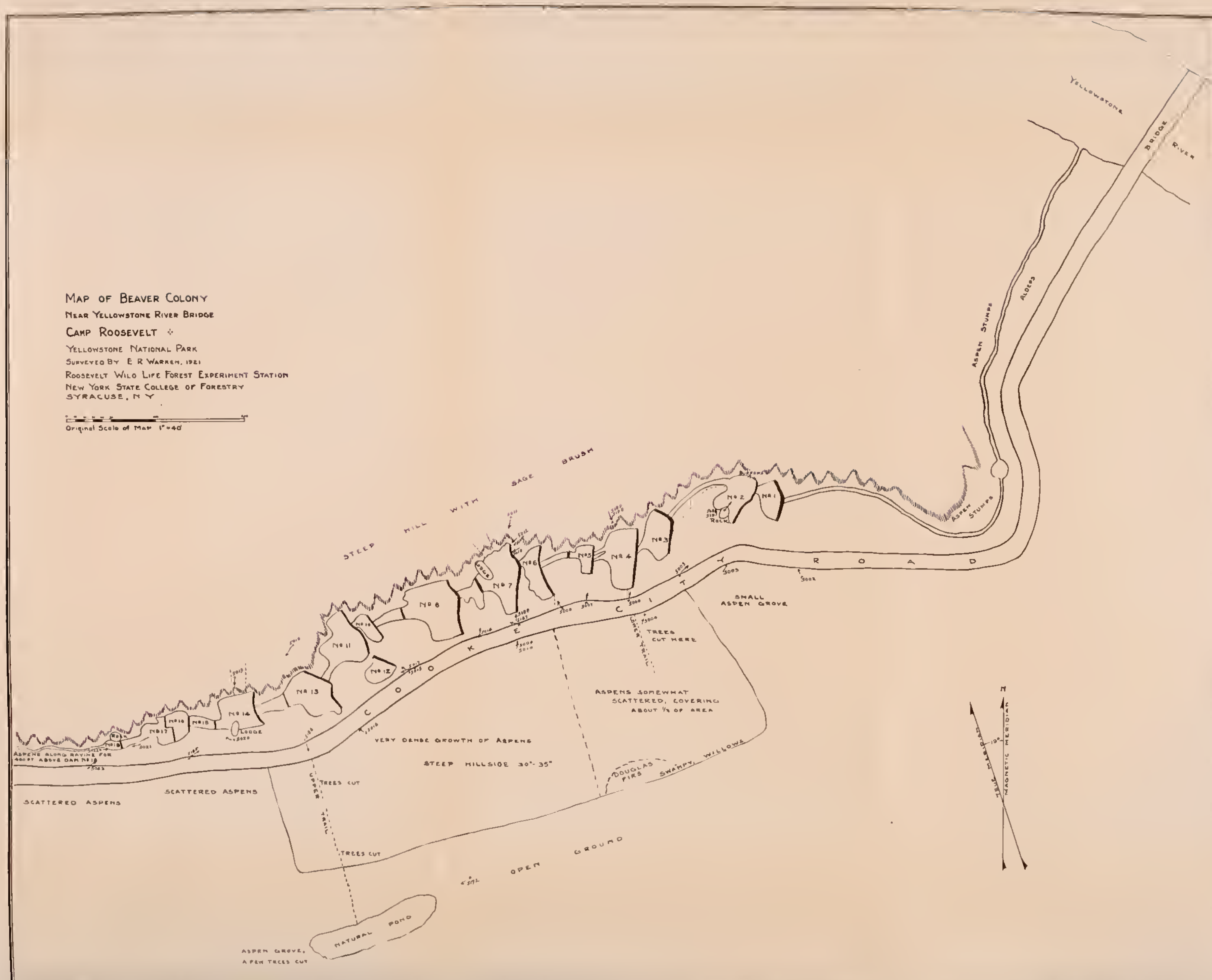
"The trappers and old men of the country say the beaver are 'coming back' in Yellowstone. At least, they are pushing their activities into places where they have not been common for some time. Just behind the corral and horse-shed at Hellroaring Ranger Station [about two miles above the mouth of the creek] two beaver have been busy since early fall. The flow of water in Hellroaring Creek is fairly swift and vigorous even at this time of year, but these industrious little animals had constructed a strong, well-built dam across nearly the whole creek bed before the ice came and hampered their work. They chose an ideal spot for the dam, where nature would help out most with the large rocks and boulders it had left there long ago. Moreover, a grove of quaking aspens grew up to the water's edge, making short hauls at that particular point a great labor-saving advantage. The cutting and dragging went on mostly at night and early morning. It was not uncommon to hear a large tree come crashing down in the middle of the night. The smaller branches were dragged to the river for the construction of the house and dam, the bark on the large limbs and trunks being peeled and eaten where they lay. Many sticks which we might easily call logs—6 to 8 inches in diameter—were cut into uniform lengths and slowly dragged into the water. I have found them floating around and stuck into the dam, peeled clean. Not less than 25 aspens were cut down, and this in the midst of many other tall trees where skillful felling seemed necessary to bring the trees to the ground.

"To the best of my knowledge all this work was done by just two beaver, a tribute to their resourcefulness, skill and industry. They showed themselves now and then during the daytime, and at such times were surprisingly unafraid. I have stood within 30 feet of one in plain view as long as I desired, with the beaver contentedly chewing the bark from a stick which he had dragged out on the ice. A hole in the ice and a well-worn trail to the aspen logs was always kept open.

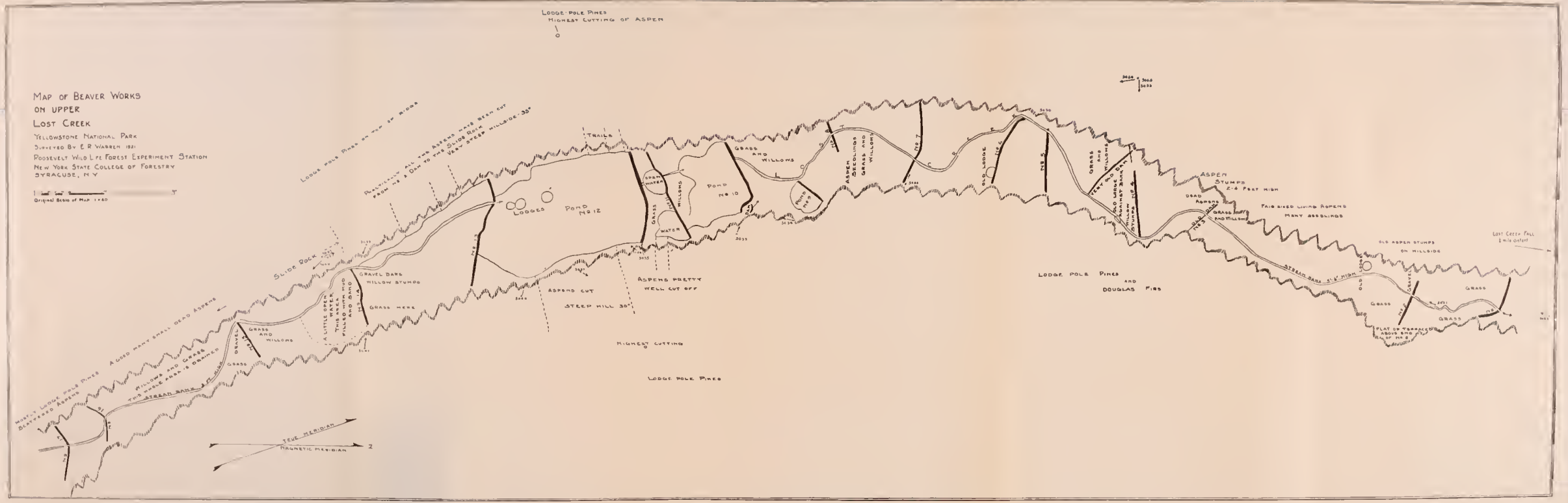
"One wonders sometimes if the beaver is not too ambitious for his own good. It is fairly safe to say that those two at Hellroaring cannot use one-fourth of the trees cut down. The whole thing seemed to be done with a lavish disregard for effort or economy. Many trees, after being slightly nibbled on, were promptly abandoned and others cut in their place. They lie there still and have never since been touched, although wood from trees much farther away has actually been cut and dragged past them."

The above statements serve to corroborate what I have already said as to the wanderings and the wastefulness of the beaver; their temporary location or return to old colony sites wherever a few aspens, sufficient to sustain a pair over winter, still stand adjacent to suitable streams; and the occasional attempts to at least partially control a strong flow of water, sufficiently to submerge their lodge and burrow entrances. Hellroaring Creek is an even larger stream than Tower Creek, along which there are signs of similar control, but no indication of the beaver having ever constructed a dam that could withstand the spring freshets.

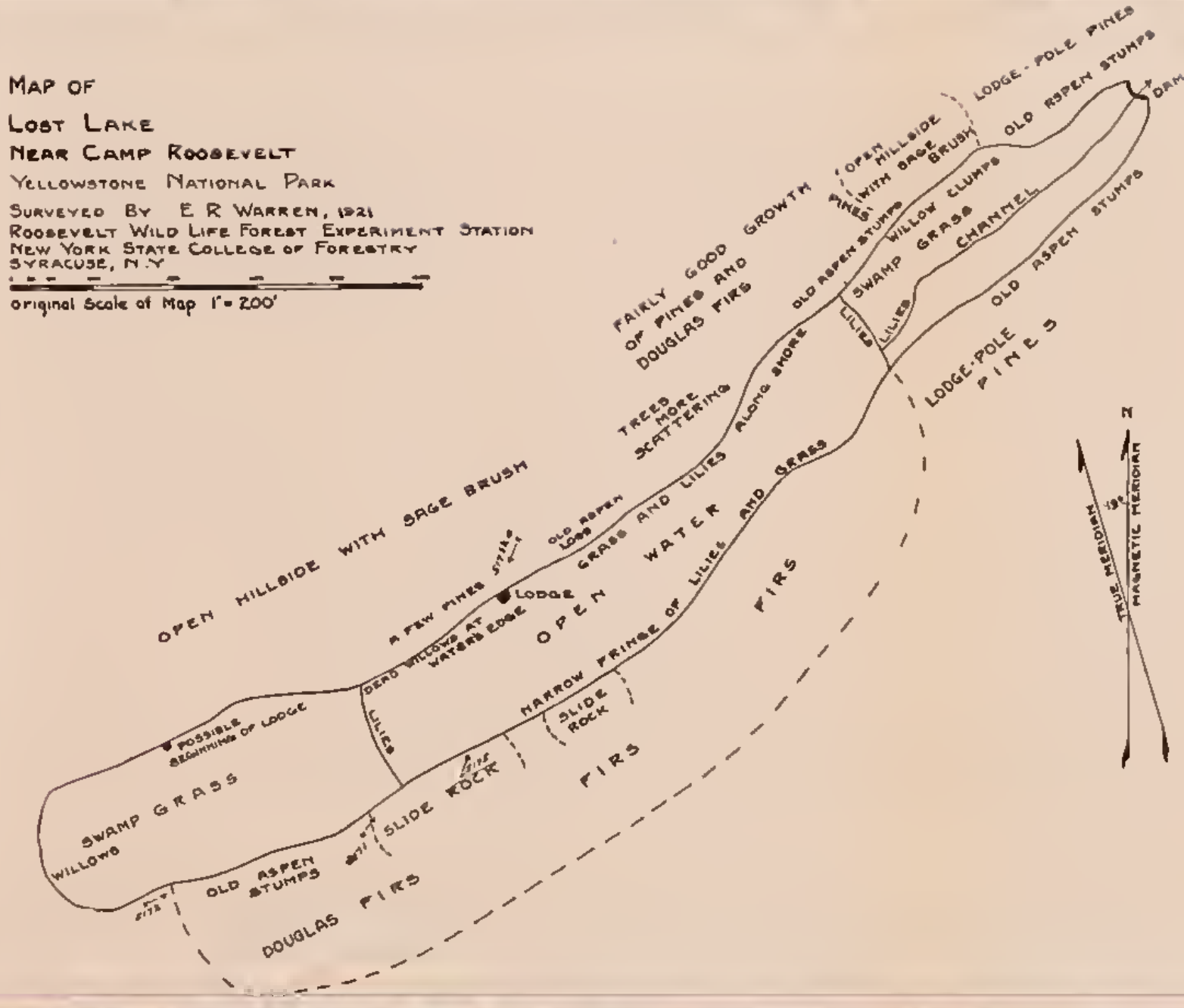
Map 2. The Tower Fall-Yancey region, Yellowstone National Park, showing location of beaver works studied in 1921.



Map 3. Beaver works on creek near Yellowstone River Bridge in 1921.

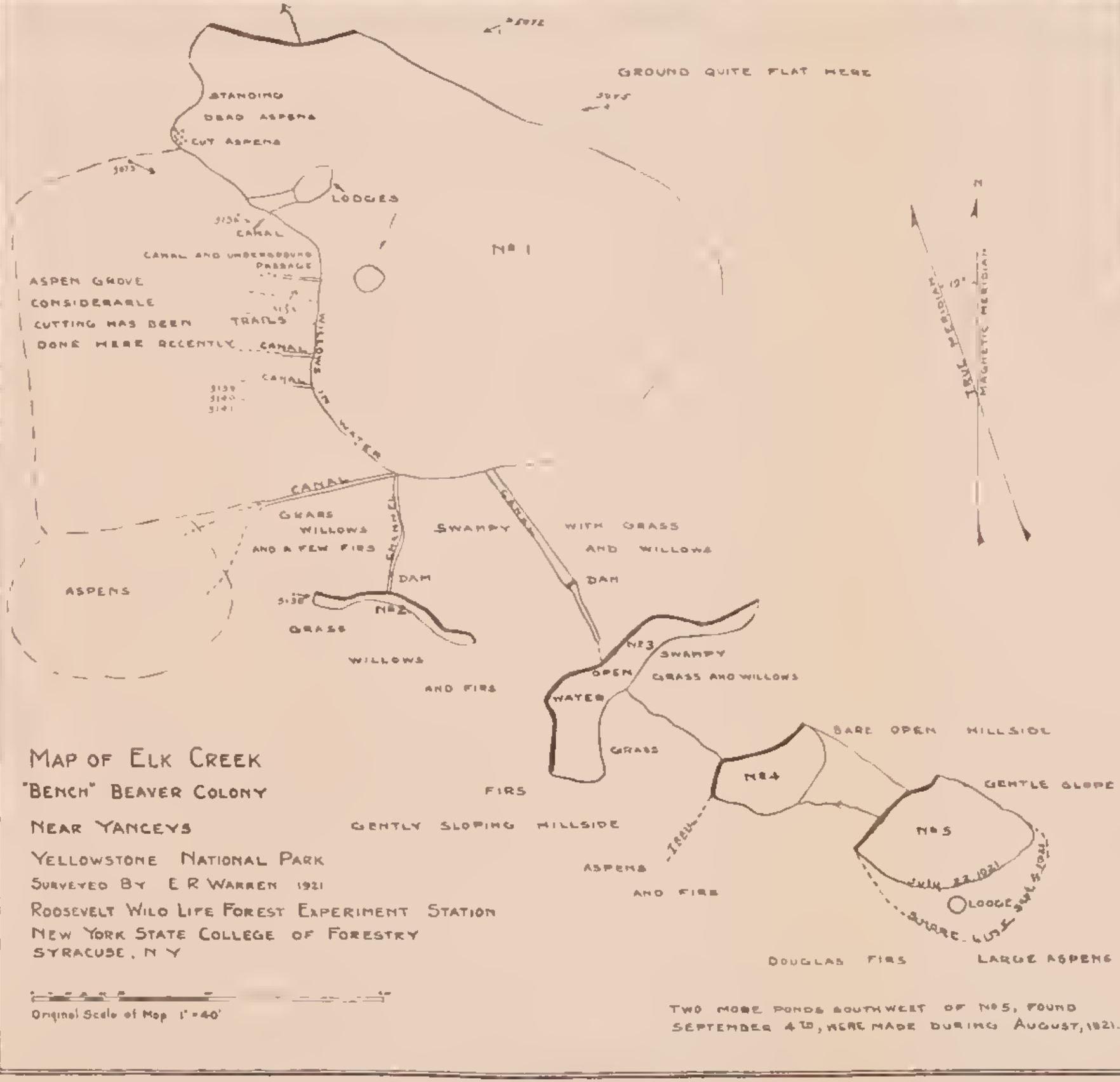


Map. 4 Beaver works on Upper Lost Creek in 1921.

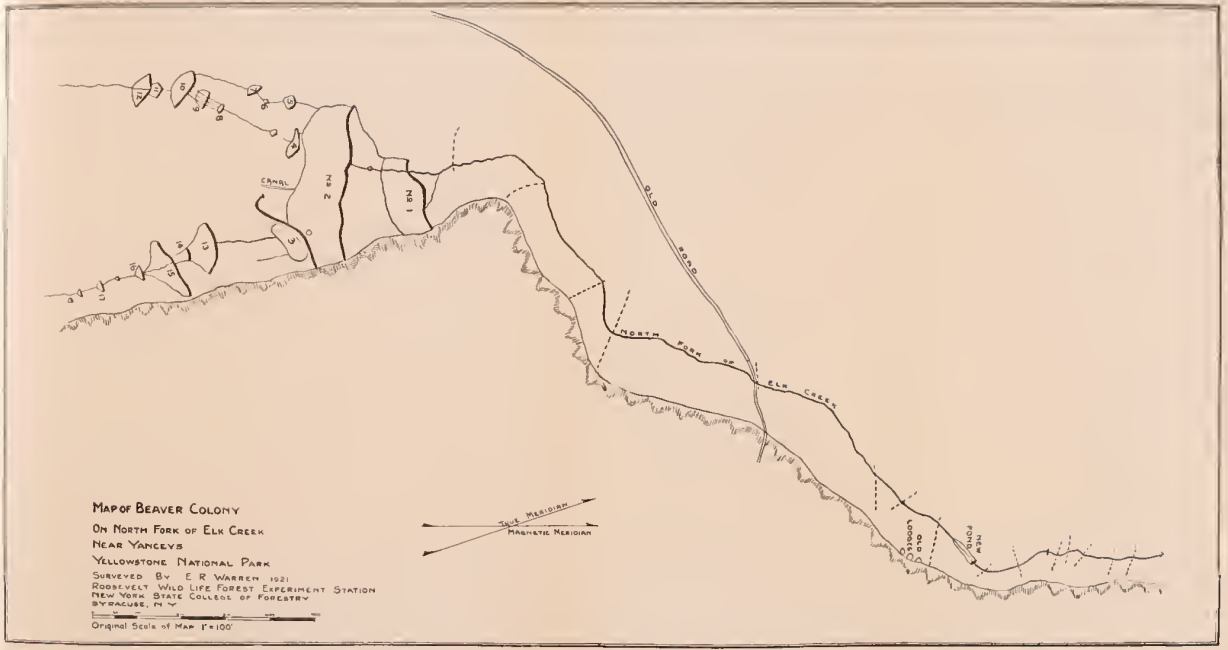


Map 5. Lost Lake, near Camp Roosevelt and Tower Fall Ranger Station, 1921.

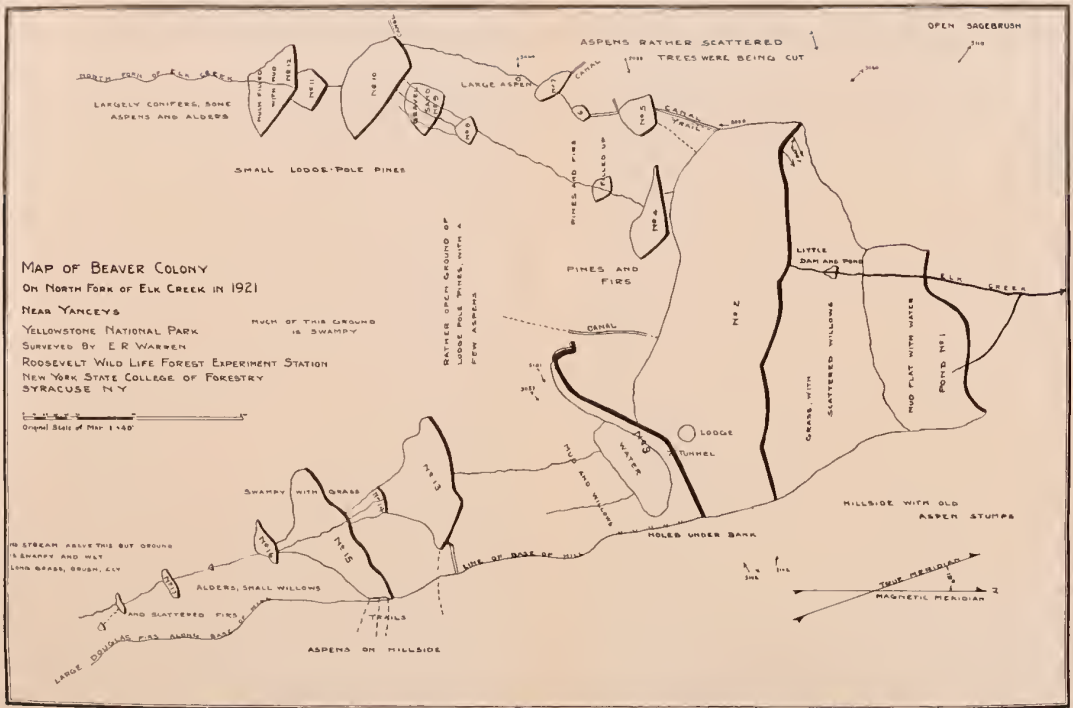
Map 6. Beaver works on the South Fork of Elk Creek, near Yanceys, in 1921.



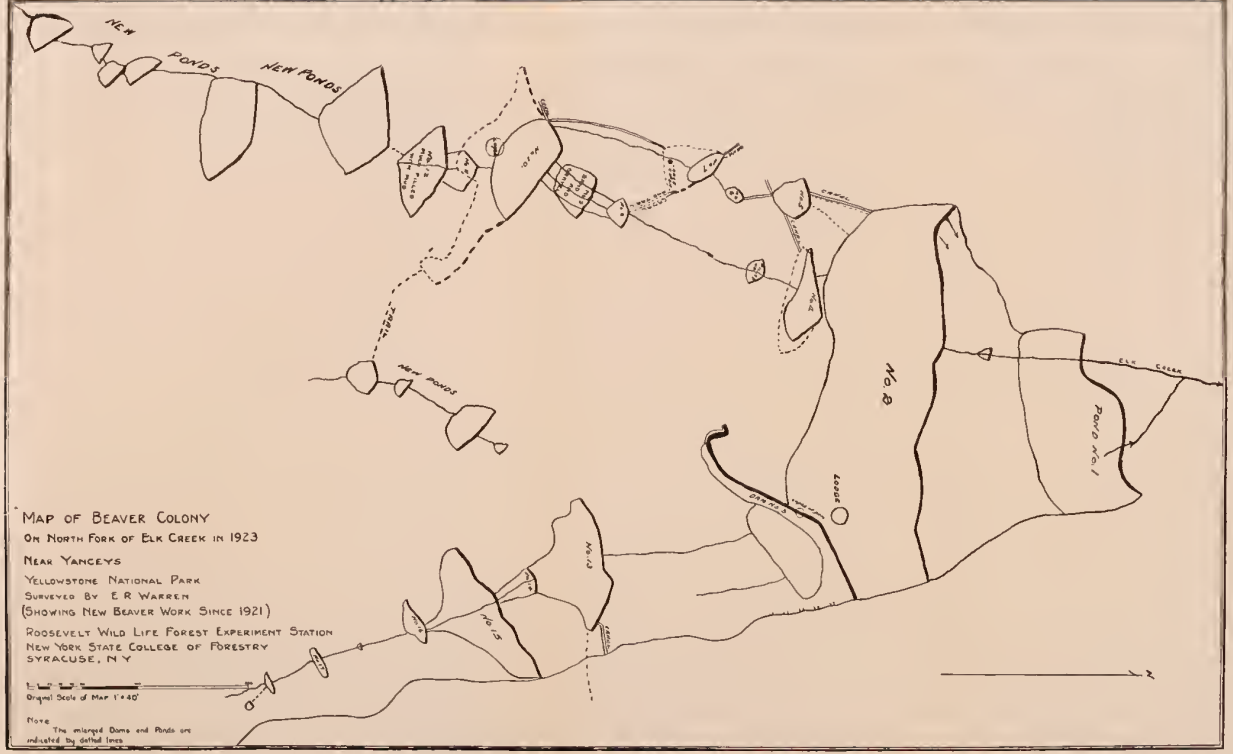
Map 7 Beaver works on The Bench head of Middle Fork of Elk Creek, near



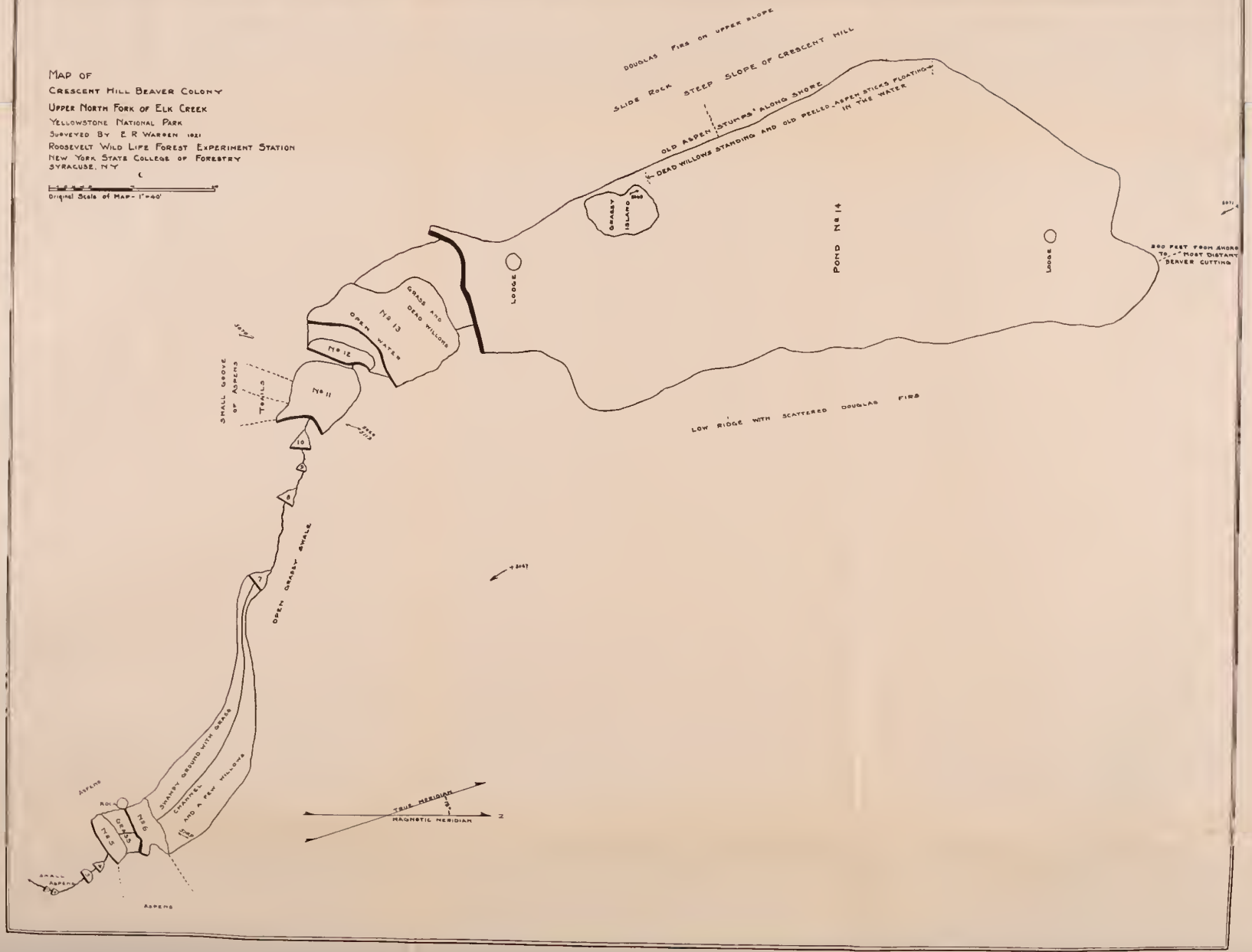
Map 8. Beaver works on the North Fork of Elk Creek in 1921. General View. Old dams are shown as dotted lines. Compare with Maps 9 and 10.



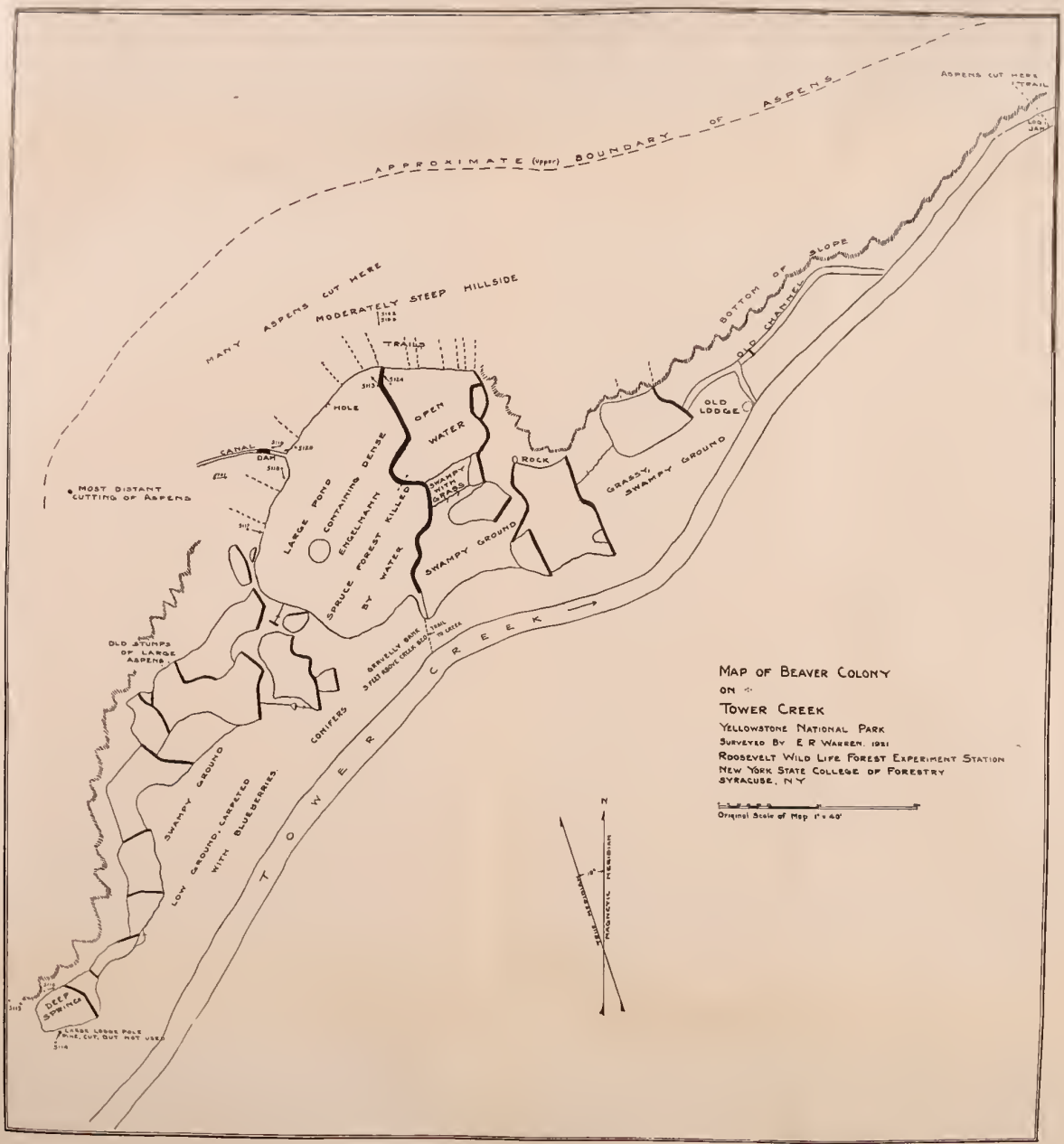
Map 9. Beaver works on Upper North Fork of Elk Creek in 1921 Compare with Map 10



Map 10. The Upper North Fork of Elk Creek in 1923, showing new beaver works constructed since 1921



Map 11. The Crescent Hill series of beaver works in 1921.



Map 12. The Tower Creek beaver works, near the Deep Spring, 1921.